Canada

Manitoba

FOREST ECOSYSTEM CLASSIFICATION
AND
LAND SYSTEM MAPPING PILOT PROJECT
SANDILANDS, MANITOBA

Prepared for

FORESTRY CANADA
(Dr. I.G.W. Corns - Scientific Authority)

and

MANITOBA FORESTRY BRANCH
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Prepared by:

PEDOCAN LAND EVALUATION LTD. (EDMONTON)
L. J. Knapik
R.A. Ellis
B. Phillips

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FOREWORD

This report summarizes the results of the second of two pilot projects to develop and test a site classification and forest land mapping system for the province of Manitoba. This pilot project summary report should not be construed to be a comprehensive field manual suitable for operational use.

As in any pilot project new concepts and procedures are being tested and reviewed prior to adoption as standard operating procedures. Any or all of the procedures can be modified or replaced, pending results of operational testing. Review comments are solicited from readers regarding concepts, procedures and management interpretations. Comments or requests for information can be addressed to :

Gerald Becker, Manitoba Forestry Branch, Winnipeg	(204-945-7951)
Ian Corns, Forestry Canada, Edmonton	(403-455-7367)
Len Knapik, Pedocan Land Evaluation Ltd, Edmonton	(403-462-5123)

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1. INTRODUCTION

1.1 PROJECT BACKGROUND

The development of a forest management site classification and mapping system for Manitoba was funded by the Canada - Manitoba Forest Renewal Agreement. Funding was shared equally by the governments of Canada and Manitoba.

The site classification and mapping system development program is managed and implemented by Forestry Canada (Ian Corns - Edmonton) and the Manitoba Forestry Branch (Gerald Becker - Winnipeg). The program has been implemented in two phases. Phase I, "Development of a Methodology and Rationale for a Forest Management Site Classification System for Manitoba" was conducted by R.E. Wells (1987) under a Supply and Services Canada contract. This work involved review of several site classification schemes and a survey of users needs; and recommended a multifactor mapping approach. Phase II involves a test application of site classification and land mapping approaches in two pilot project areas. The Duck Mountain Pilot Project was conducted in 1987-88 (Knapik et al. 1988), and the Sandilands Pilot Project (this report) was conducted in 1988-89 by Pedocan Land Evaluation Ltd. (Edmonton) under a Supply and Services Canada contract.

1.2 TERMS OF REFERENCE

The primary objectives of the Pilot Projects were identified under Supply and Services Canada contract 01K45-7-0031. The Statement of Work can be summarized as follows:

1. To be familiar with the present MFB site classification system and other potentially applicable studies.

2. To classify the pilot area within the Ecoregions-Subregions of Adams (1985).

3. To map ecological site units at 1:50,000 scale based upon landforms, soils, plant community types, etc. Sample plots to be described after Walmsley et al. (1980).

4. To characterize map units by productivity estimates of site index (SI) and mean annual increment (MAI) of dominant and sub-dominant site types within map units using MFB cruise and permanent sample plot data. (This is best done in the ARC/INFO environment during an operational testing phase.)

5. To classify and describe the various forest ecosystems. Non-productive wetland ecosystems are not classified.

6. To develop examples of keys to the site units for field testing by operational foresters and forestry technicians.

7. To traverse a wide variety of sites with experienced MFB personnel and record successes and failures of various forest management activities.

8. To categorize management interpretations, particularly those related to reforestation silviculture by site type/map unit.

9. To develop additional qualitative interpretations for site and map units.

10. To develop empirical relationships between SI, MAI, and site factors using stepwise multiple regression or other appropriate multivariate statistical methods. Identify key site factors that can be interpreted from air photos and help in defining ecological map unit concepts.

11. To prepare site map on 1:50,000 base map for digitization by MFB into GIS.

12. To prepare interim and final reports and maps.

2. SAMPLING AND ANALYTICAL METHODS

2.1 FIELD SAMPLING

The objectives of field sampling were to:

1. Provide a vegetation and soil data base for the ecosystem classification, and
2. Groundtruth the Land System mapping.

Sample plots were located on representative, modal forest sites. Sample plots were located in relatively homogeneous sites. Sites with obviously discontinuous vegetation, soils or topography, such as ecotones, or edge-effect areas, were avoided. Sampling was confined to forested sites. Thus, farmlands and non-treed wetlands were not sampled and farmlands were not mapped. Logged areas also were not sampled, but they were included in the mapping. Both seral and climax vegetation were sampled. Site selection was biased towards the selection of typical landform-soil-moisture regime situations - not always tree species. The range and selection of landform-soil-forest types was very limited in the pilot area.

Field sampling followed the methods and data forms given in Walmsley et al. (1980). More detailed descriptions of methods and sampled variables are available in Walmsley et al. (1980).

Vegetation sample plots were circular, with an area of 0.01 hectare. Within each plot, canopy cover (Daubenmire 1959) was estimated to the nearest percent for every plant species in each layer, and for each layer in total. Plants with less than 1% cover were considered to have 0.5% cover. The layers recognized were:

1. Tree Layer (>10 m);
2. Tall Shrub Layer (2-10 m);
3. Low Shrub Layer (<2 m);
4. Herb Layer (includes dwarf-shrubs); and
5. Moss Layer (includes terrestrial mosses, liverworts and lichens).

The tree layer was further divided into veteran, dominant, main, and low layers depending on the relative age, height, and canopy cover of the trees (see Walmsley et al., 1980).

Voucher specimens were collected for most plant species and will be deposited in the Forestry Canada Herbarium, Edmonton. Epiphytes and fungi were neither listed nor sampled. Species nomenclature follows Scoggan (1957).

A number of site and landscape features were assessed in each plot, including:

1. Aspect;
2. Slope;
3. Landform and Surface Expression;
4. Macro and Meso Site Position;
5. Ecological Moisture Regime;
6. Nutrient Regime;
7. Soil Drainage;
8. Depth to Water Table, Effective Rooting, and Carbonate;
9. Vegetation Successional Status;
10. Humus Form; and
11. Percent Cover of the Different Substrate Types in the plots.

Furthermore, a site position, cross-sectional diagram was drawn for each plot.

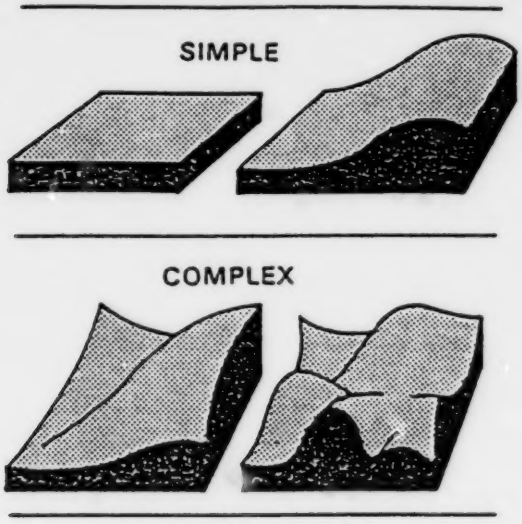
A soil pit was dug in the center of each plot. Profile descriptions were made, including information on:

1. Horizon designation, depth, and thickness;
2. Coarse Fragments;
3. Texture;
4. Structure;
5. Consistence;
6. Color;
7. Mottles; and
8. Organic Materials.

Guidelines for describing site and soil properties are found in Walmsley et al. (1980), and some of the main concepts are described in the following figures and tables.

At 11 plots selected for their representativeness, bulked soil samples were collected from each horizon for lab analysis (see Section 2.2). In most other plots soil samples were collected for additional pH determinations.

SLOPE



SITE POSITION ON SLOPE

A CREST - the generally convex upper most portion of a hill (meso scale) - it is usually convex in all directions, no distinct aspect

B UPPER SLOPE - - the generally convex upper portion of the slope of a hill (meso scale) immediately below the crest - it has a convex surface profile with a specific aspect

C MIDDLE SLOPE - the area of the slope of a hill between the upper slope and the lower slope, where the slope profile is not generally concave or convex - it has a straight or somewhat sigmoid surface profile with a specific aspect

D LOWER SLOPE - the area toward the base of the slope of the hill, is generally has a concave surface profile with a specific aspect.

E TOE - the lower part of the slope. Area defined by excess of homogeneous area of slight slope and/or sometimes clearly demarcated by an abrupt levelling of the slope. Often characterized by seepage.

F DEPRESSION - at the foot of a meso scale mound or an generally level area, any area that is concave in all directions

G LEVEL - any level meso scale area not immediately adjacent to a meso scale mound. Surface profile generally horizontal no aspect

Courtesy: Ontario Institute of Pedology

Figure 1. Guide to slope type and site position.

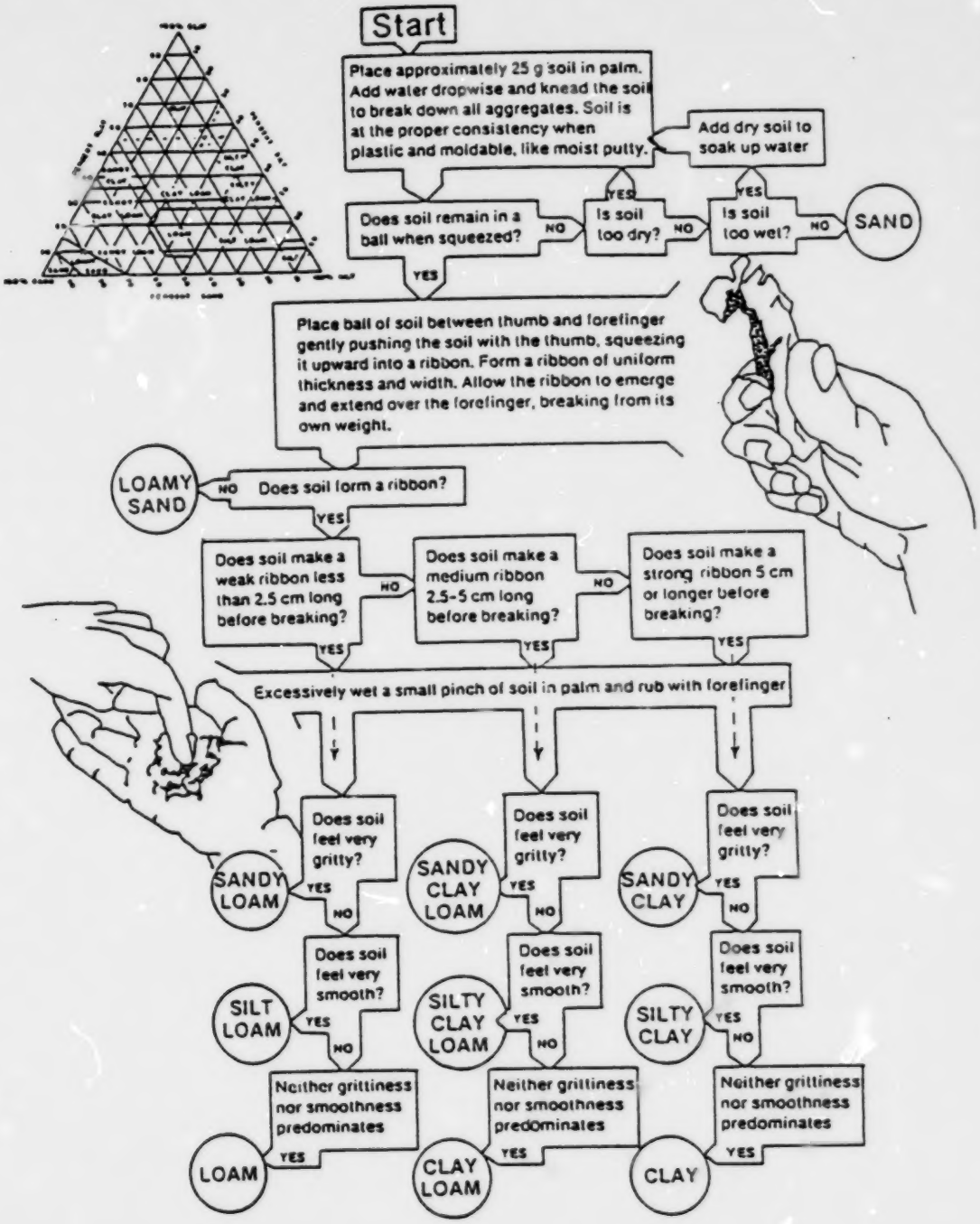
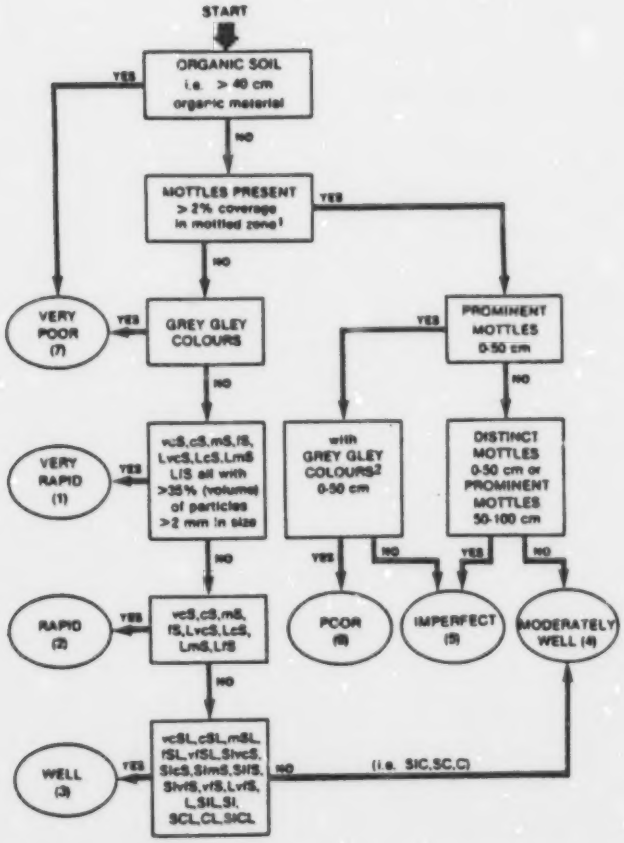

Start
Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.
Add dry soil to soak up water
Does soil remain in a ball when squeezed?
NO
Is soil too dry?
YES
NO
Is soil too wet?
YES
NO
SAND
YES
Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.
LOAMY SAND
NO
Does soil form a ribbon?
YES
Does soil make a weak ribbon less than 2.5 cm long before breaking?
NO
Does soil make a medium ribbon 2.5-5 cm long before breaking?
NO
Does soil make a strong ribbon 5 cm or longer before breaking?
YES
YES
YES
Excessively wet a small pinch of soil in palm and rub with forefinger
Does soil feel very gritty?
SANDY LOAM
YES
NO
Does soil feel very smooth?
SILT LOAM
YES
NO
Neither grittiness nor smoothness predominates
LOAM
YES
Does soil feel very gritty?
SANDY CLAY LOAM
YES
NO
Does soil feel very smooth?
SILTY CLAY LOAM
YES
NO
Neither grittiness nor smoothness predominates
CLAY LOAM
YES
Does soil feel very gritty?
SANDY CLAY
YES
NO
Does soil feel very smooth?
SILTY CLAY
YES
NO
Neither grittiness nor smoothness predominates
CLAY
YES

Figure 2. Instructional diagram for determining soil texture by feel (Thien, S.J., 1979. J. of Agronomic Education, Vol. 8)



1. Exclude mottles that are few or faint
2. Gley Colours
   Chroma 1, any hue
   Chroma 2, hues 10 YR or redder
   Chroma 3, hues yellower than 10YR
   any chroma, hues bluer than 10Y
   any chroma, reddish hues

S = SAND or SANDY
Sl = SILT or SILTY
L = LOAM or LOAMY
C = CLAY

vc = very coarse
c = coarse
m = medium
f = fine
vf = very fine

examples:
vcS = very coarse SAND
LvfS = LOAMY very fine SAND
SICL = SILTY CLAY LOAM

Figure 3. Soil drainage (Jones et al., 1983).

Table 1. Ecological moisture regime classes (after Walmsley et al., 1980).

Moisture regime	Description	Primary water source	Slope position
0 Very xeric	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation	Precipitation	Ridge crests shedding
1 Xeric	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation	Precipitation	
2 Subxeric	Water removed rapidly in relation to supply; soil is moist for short periods following precipitation	Precipitation	Upper slopes shedding
3 Submesic	Water removed readily in relation to supply; water available for moderately short periods following precipitation	Precipitation	
4 Mesic	Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year; available soil moisture reflects climatic inputs	Precipitation in moderately to fine-textured soils & limited seepage in coarse-textured soils	Mid-slope normal rolling to flat
5 Subhygric	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm	Precipitation and seepage	Lower slopes receiving
6 Hygric	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying	Seepage	
7 Subhydric	Water removed slowly enough to keep the water table at or near the surface for most of the year; gleyed mineral or organic soils; permanent seepage less than 30 cm below the surface	Seepage or permanent water table	Depressions receiving
8 Hydric	Water removed so slowly that the water table is at or above the soil surface all year; gleyed mineral or organic soils	Permanent water table	

[1] Texture symbols are as follows: L = loam(y), S = sand(y), and Si = silt(y).

Table 2. Nutrient regime characteristics[1] (after Walmsley et al., 1980).

	A. Oligotrophic	B. Submesotrophic	C. Mesotrophic	D. Permesotrophic	E. Eutrophic	F. Hypereutrophic
Definition	Very poor nutritional status, very small supply of available nutrients	Poor nutritional status, low supply of available nutrients	Medium nutritional status, medium supply of available nutrients	Rich nutritional status, plentiful supply of available nutrients	Very rich nutritional status, abundant supply of nutrients	Saline nutritional status, excess salt accumulations
Bedrock source	Granite, Rhyolite, Quartzite, Quartz sandstone	Granodiorite, Dacite, Quartz gneiss, Conglomerate	Diorite, Andesite, Garnet schist, Graywacke	Gabbro, Basalt, Biotite schist, Argillite, Shale	Peridotite, Dunite, Slate, Phyllite, Dolomite, Limestone	Serpentine, Marble, Gypsum, Halite
Texture	Very coarse	Coarse	Medium	Fine	Very fine	Variable
Organic matter content	Low	Moderate		High		Variable
Humus form	Acid mors	Mors and moders		Moders and mulls		
Soil reaction	Extremely acid to medium acid	Medium acid to neutral		Slightly acid to mildly alkaline		Moderately to strongly alkaline
Cation exchange capacity	Low	Moderate		High		Variable
Base saturation	Low	Moderate		High		Variable
Carbon/nitrogen ratio	High	Moderate		Low		Variable

1 The presence of nutrient-rich seepage waters may compensate for other factors to create eutrophic conditions.

Table 3. Soil mineral horizon and modifier descriptions.

Ah, Ap	Dark-colored, mineral, surface horizons, enriched with organic matter (p is man modified, e.g., plow layer)
Ae	Light-colored, near surface horizon; horizon of loss of iron, aluminum, organic matter, or clay
AB	Transition horizon from A to B
Bt	Brownish subsurface horizon, enriched with clay that has been moved from the Ae horizon
Bm	Brownish subsurface horizon with only slight addition of iron, aluminum, or clay
Bf, Bhf	Reddish-brown subsurface horizon; significant accumulation of iron, aluminum, and/or organic matter
Bg	Horizons with grey gley colors, mottling, or both
BC	Transition horizon from B to C
C	Relatively unweathered material from which the soil profile has developed
Ck	C horizon containing calcium and/or magnesium carbonates that will effervesce with dilute HCl
j	Used with suffixes e, f, g, and t to denote an expression of but failure to meet the specified limits of the suffix it modifies (e.g., Bfj, Ckgj)
Solum	A and B horizons in which the parent material (C) has been modified

ROMAN NUMERALS:

Roman numeral two (II) preceding the horizon designation indicates a significant change in texture (mode of decomposition) within the profile, e.g., silty loam over coarse sand.

[1] For more information on soils description and classification, see Canada Soil Survey Committee (1978), and Walmsley et al. (1989).

Table 4. Forest humus horizons and humus types.

L, F, H	Organic horizons developed primarily from the accumulation of leaves, twigs, and woody material with or without a minor component of mosses; usually not saturated for prolonged periods; >17% organic C (approximately 30% organic matter by weight)
L	Characterized by an accumulation of mainly leaves (and needles), twigs, and woody materials; some of the original structures are easily discernible
F	Characterized by an accumulation of partly decomposed organic matter derived mainly from leaves, twigs, and woody materials; some of the original structures difficult to recognize; material may be partly comminuted by soil fauna, as in a moder, or it may be a partly decomposed mat permeated by fungal hyphae, as in mor
H	Characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible; differs from the F by having greater humification chiefly due to the action of organisms; it may be sharply delineated from the mineral soil, as in a mor where humification is chiefly dependent upon fungal activity, or it may be partially incorporated into the mineral soil, as in a moder
Ah	Mineral horizon enriched with organic matter (<17% organic C by weight)
Of, Om, Oh	Organic horizons developed mainly from mosses, rushes, and woody material; >17% organic C (approximately 30% organic matter by weight)
Of (fibric)	The least decomposed organic horizon, containing large amounts of organic fiber (von Post 1-4)
Om (mesic)	An intermediately decomposed soil horizon with properties intermediate of an Of and Oh (von Post 5 and 6)
Oh (humic)	The most decomposed organic horizon, containing only small amounts of well preserved fiber and the major amount of material at an advanced state of decomposition (von Post 7-10)

2.2 SOIL LABORATORY ANALYSES

Soil analyses were conducted using procedures (Table 5) adopted by the Canada Soil Survey Committee (McKeague, 1978). The sample depths and types of analysis were chosen to identify the soil parameters usually related to moisture and nutrient supply to trees and other plants.

Table 5. Methods of soil analysis.

Soil Property	Method
pH	1:2 H_2O and $CaCl_2$
Calcium Carbonate Equivalent	gravimetric loss, 3M HCl
Extractable Cations (Ca, Mg, Na)	ammonium acetate, pH 7, atomic absorption
Organic Matter	Loss on Ignition
Total N	semi-micro Kjeldahl, NO_3+NO_2 not included
Particle Size Analysis	Two point hydrometer

2.3 SITE PRODUCTIVITY ANALYSIS

2.3.1 VARIABLES USED IN THE STUDY

Simple correlation analyses and scatter plots were used to investigate possible relationships between the two productivity measures (SI, MAI) and the continuous independent variables listed in Table 6.

For the discrete variables listed in Table 6, analysis of variance (ANOVA) techniques were applied. Because of the difficulty in making valid statistical inferences when some cells contain only one observation, only cells with two or more observations were included in the actual ANOVA calculations. For significant variables, the Student-Newman-Keuls (SNK) multiple comparison procedure (Steel and Torrie 1980) was then used to evaluate significant differences between categories.

Table 6. Variables used in the study.

a)	Continuous Variables		
	BHAGE	-	age of tree at breast height (1.3 m)
	CONVOL	-	coniferous volume for plot (m^3 ha^{-1})
	DECVOL	-	deciduous volume for plot (m^3 ha^{-1})
	ELEV	-	elevation of plot (m)
	FRAGA	-	percentage of coarse fragments in A horizon
	FRAGB	-	percentage of coarse fragments in B horizon
	FRAGC	-	percentage of coarse fragments in C horizon
	HUMDEPTH	-	humus depth (cm)
	MAI	-	mean annual increment (m^3 ha^{-1} yr^{-1})
	PHLFH	-	pH of LFH layer
	PHA	-	pH of soil in A horizon
	PHB	-	pH of soil in B horizon
	PHC	-	pH of soil in C horizon
	SI	-	site index (m)
	SOLDEPTH	-	solum depth (cm)
	TOTAGE	-	total age of tree
	TOTVOL	-	total coniferous and deciduous volume (m^3 ha^{-1})
b)	Discrete Variables		
	DRAINAGE	-	soil drainage (6 classes)
	HUMFORM	-	humus form (4 classes)
	LANDFORM	-	landform (5 classes)
	MACRO	-	macro slope position (2 classes)
	MESO	-	meso slope position (5 classes)
	MOISTURE	-	moisture regime (7 classes)
	NUTRIENT	-	nutrient regime (6 classes)
	SOILGRP	-	soil group (15 classes)
	SOILSER	-	soil series (10 classes)
	SUBREG	-	subregion (2 classes)
	TEXA	-	texture of soil in A horizon (8 classes)
	TEXB	-	texture of soil in B horizon (16 classes)
	TEXC	-	texture of soil in C horizon (12 classes)

2.3.2 DETERMINATION OF MAI

All trees within a 0.01 ha plot were recorded by species, diameter at breast height (dbh) and height. This data was input into the following Manitoba tree volume equation to estimate gross merchantable volumes:

$$V = a + \frac{b \cdot D^2 \cdot H}{100}$$

where:

- V = gross merchantable volume (m^3)
- D = dbh (cm)
- H = height (m)
- a,b = coefficients which vary with species and dbh

All tree volumes were then summed and the plot volume multiplied by 100 to give total volume per hectare (TOTVOL).

Age at breast height (1.3 m) was taken for one tree on each plot. This age was converted to stump age by use of Alberta Forest Service equations which predict the number of years from stump to breast height as a function of species and site index (Alberta Forest Service 1985). Total age (TOTAGE) was then assumed to be the same as stump age for deciduous species but 5 years more than stump age for coniferous species.

Finally MAI was determined by dividing total volume by total age.

2.3.3 DETERMINATION OF SI

On the basis of the height and age of each sample tree, SI was determined using site index curves from Minnesota (supplied by MFB - see Appendix I).

SI was not subdivided by species because only 3 of 7 species were sampled more than once. And of these 3, only jack pine (26 trees) had any significant representation[1]. Sites were selected to represent landform units as a first criteria. Wetland

[1] Of the other 2 species, white spruce was represented by 5 trees and black spruce by only 2 trees.

sites were mostly avoided. A large percentage of the pilot area had young plantations unsuitable for sampling, which severely limited the selection of forest cover type by landform - soil unit.

2.3.4 ANALYSIS OF CONTINUOUS INDEPENDENT VARIABLES

Simple correlation analysis was used to evaluate the relationships between the two productivity measures and the two independent variables that are continuous: slope and silt-clay content. Scatter plots were checked for the presence of nonlinearity in the relationships. It should be pointed out that the percent cover data by species was not utilized because plot representation was inadequate for partitioning the population by species. Note that there were 155 species but only 41 plots. Therefore there is a very high probability of observing significant differences which have in fact occurred by chance alone.

2.3.5 ANALYSIS OF DISCRETE VARIABLES

Analysis of variance (ANOVA) was used when the independent variables were discrete. For variables that were significant, range tests based on the Student-Newman-Keuls test (Steel and Torrie 1980) were performed.

Finally, two-way ANOVA and analysis of covariance were used in a few cases to check for interactions among certain variables.

3. CLASSIFICATION AND MAPPING

3.1 BASIC CONCEPTS

The separate and distinct concepts of forest site classification and forest land mapping must be appreciated. Classification is the creation and definition of classes. Classes are groups of individuals with common properties or relationships that are seen to be similar for a particular purpose. Classes can be formed by grouping individuals or by subdividing populations. Four general types of classification systems (soil, terrain, site and land) have traditionally been applied to forest land (Valentine, 1986). The classes or categories in such classification systems are usually structured hierarchically - that is narrowly defined classes can be grouped into more general classes.

Mapping is the delineation and description of different portions of a land area. It may be accomplished by grouping small areas that are similar, or by dividing an area into portions that are different, or (usually) by a combination of these techniques. Mapping is actually a form of classification, but it identifies the location and pattern of the classes (or map units) in a landscape. There are three basic reasons to classify and map the forest land base:

1. More precise statements can be made about the subdivisions of a region than can be made about the region as a whole.

2. More general statements can be made about a group of types than can be made about an individual type within the group.

3. We can use a short name or number to refer to a type without listing all of its properties.

For further background reading on forest land classification and mapping the reader is referred to an excellent Canadian textbook by Valentine (1986).

3.2 GUIDELINES

The contract terms of reference provided the general guidelines to:

1. Classify the pilot area within the Ecoregions-Subregions concepts of Adams (1985), and

2. Map ecological site units at 1:50,000 scale based upon landforms, soils, plant communities, etc.

Phase I of this program (Development of a Methodology and Rationale for a Forest Management Site Classification System for Manitoba) provided very general recommendations for an approach such as:

"An ecological mapping - site classification approach using modern methods of data analysis is therefore recommended as the best available method to achieve a unified site classification framework for solving major site-related forestry problems in Manitoba."
(Wells, 1987; p. 82)

"The "Recommended Methodology" to be followed was as follows:

1. Selection of priority areas for pilot studies. As a start, two pilot areas, each at least three to four townships in size, could be selected to represent major kinds of forest conditions in Manitoba. One of these areas should probably be selected where there is a good supply of site related information. The other area could be selected where such information is sketchy or unavailable.

2. Photo interpretation and detailed mapping of the pilot areas, using Manitoba Forestry Branch aerial photography (1:15,840) with cover-type boundaries, and also using an initial map legend based on existing information as demonstrated by this study.

3. Detailed field sampling within and possibly also outside pilot areas in order to collect data needed to identify and adequately characterize site units and their variability. Information collected at sample plots would include detailed descriptions of soil, site and vegetation properties, and forest productivity data for site index and mean annual increment comparisons. Soil samples would also be collected for laboratory characterization of soils representative of site units. Ecological field plot forms available from other provinces could be used or modified for Manitoba conditions as required.

4. Computer file input of collected data. Use of dataloggers or microcomputers is recommended for most efficient and cost effective data entry.

5. Computer-aided analysis of collected data, including results of soil laboratory analysis, to characterize site classification units.

6. Revision of site mapping legend as required.

7. Digitize final site maps for input on ARC/INFO.

8. Development of interpretative keys using results from the computer aided analysis. Input from experienced operational forestry personnel should also be used to develop these interpretative keys.

9. Preparation of initial field guide to be used in conjunction with site maps and interpretative keys for technology transfer testing before adopting an operational program. Field guide should be modelled on those prepared for Ontario (Jones et al., 1986) and Alberta (Corns and Annas, 1986) for convenient use in the field.

10. Field examination of site units in the company of experienced operational foresters at various intervals in order to evaluate the development and use of site classes, site maps and interpretative keys for operational purposes. This combined input and technical transfer process is regarded as critical to developing a forest site classification that can be used by operational personnel."

(Wells, 1987; p. 83, 84, 85)

These recommendations apply mostly to process and provide only general considerations for classification rather than a structure.

Review of the Phase I report and other available information and discussions with Forestry Canada and MFB personnel resulted in identification of the following guiding principles:

1. The system should be useful for operational planning of sites (0.5 to 2 ha minimum size), but also for regional planning of large areas.

2. The system should be applicable at reasonable cost to very large areas of land with limited ground access, and very little available information.

3. The system should provide information requirements for silvicultural and harvesting planning requirements.

4. The system should be relatively simple and easy to use, and should favour a pragmatic rather than a puristic approach.

3.3 THE PROPOSED MAPPING SYSTEM

The Land System mapping approach generally follows the concepts of the Canadian Ecological Land Classification (ELC) system (Wiken et al., 1980). The ELC system provides a hierarchical framework to classify and map landscapes at various levels of detail. The levels in the ELC system are:

- Ecoprovince (also called Ecozone)
- Ecoregion
- Ecodistrict (also called Land District)
- Ecosection (also called Land System)
- Ecosite
- Ecoelement

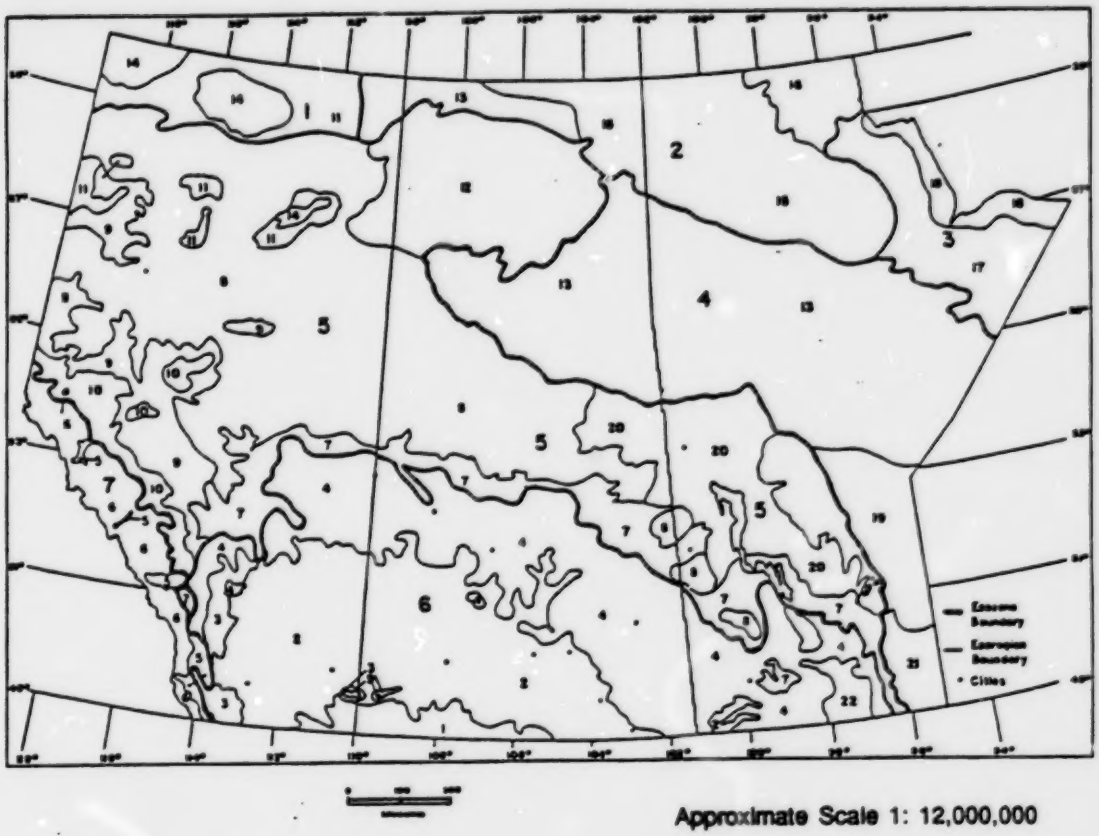
An ecological map base for the Prairie Provinces was published by Adams (1985) that identifies Ecoregions and Habitat Subregions at 1:1,000,000 scale. The source of information used for Manitoba was from Manitoba Soil Survey (Mills 1980, 1983). Since this database is published and is suitable for an upper-level classification of forest land it was adapted for this pilot study. ELC (biophysical) surveys have been conducted for much of northern Manitoba by Canada - Manitoba Soil Survey.

The hierarchy of land classification used in the pilot projects departs somewhat from the classical terminology of the ELC system to be as follows:

- Ecozones (part of Boreal Plains)
- Ecoregion . . } Defined by Adams (1985) and mapped
- Habitat Subregion } at 1:1,000,000
- Land System - mapped at 1:50,000
- Forest Ecosystem - used to classify a site

ECOREGIONS (from Adams 1985)

An Ecoregion is a general land mapping level characterized by broad divisions of land integrating macro-biota and soil indicators of latitudinal gradients of climatic change (Rowe 1979). According to the Environmental Conservation Task Force (1981), ecoregions are assemblages of regional landforms characterized by distinctive ecological responses to climate as expressed by development of vegetation, soils, water and fauna. Ecoregions are recognized by assemblages of soil great groups, plant regions, meso climate, large water basins and faunal communities. Ecoregions and the larger ecozones of the Prairie Provinces are shown in Figure 4.



Approximate Scale 1: 12,000,000

Figure 4. Ecozones and Ecoregions - Prairie Provinces.

Ecozones

1 - Taiga Plains
2 - Taiga Shield
3 - Hudson Plains
4 - Boreal Shield
5-Boreal Plains
6-Prairie
7-Montane Cordillera

Ecoregions

1 - Short-grass Prairie
2 - Mixed-grass Prairie
3 - Fescue Prairie
4 - Parkland
5 - Montane
6 - Mountain Complex
7 - Mid-Boreal Transition
8 - Mid-Boreal Mixedwoods
9 - Mid-Boreal Foothills
10 - Boreal Uplands
11 - High Boreal Plains
12-High Boreal Sandplain
13-High Boreal Precambrian
14-Low Subarctic Uplands
15-Low Subarctic Precambrian
16-High Subarctic
17-Hudson Bay Lowlands
18-Coastal Lowland
19-Mid-Boreal Precambrian
20-Mid-Boreal Lowlands
21-Low Boreal
22-Tall-grass Prairie

Source: Adams (1985) based on Harris et al. 1983, Millar 1976, Mills 1979, Padocan 1983, Wilken 1985 and Zoltai 1975.

HABITAT SUBREGIONS (from Adams 1985)

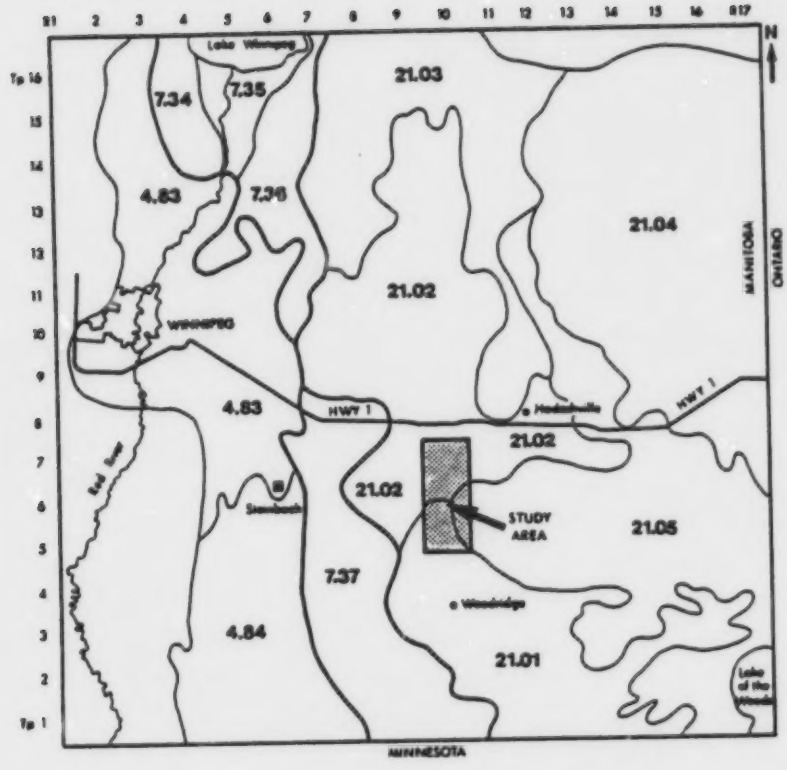
A Habitat Subregion is a landscape division of the ecoregion delineated at the third hierarchical level. It is defined by elevation, relief, regional surface form, drainage and by broad genetic materials (Pedocan 1983). Each subregion is conceptually similar to ecodistricts, but is characterized less by homogeneity of surface materials, and more by similarities in landform, vegetation components, and wetland distribution patterns. Examples of habitat subregions are glacial-fluvial-lacustrine plains, hummocky moraines, and bedrock controlled plateaus. Subregions of southeastern Manitoba are illustrated in Figure 5.

LAND SYSTEMS

A Land System is a unit or pattern of land, mappable at 1:50,000, that is distinguished (on 1:50,000 airphotos) from adjacent land on the basis of surface form, materials, and hydrology. Forest cover is often a clue to materials and hydrology but is not diagnostic of Land Systems. A Land System may be relatively homogeneous (eg. a large bog, or a lacustrine plain) or it may be highly heterogeneous (eg. a hummocky moraine with dry and wet sites, including small bogs). The Land System can however be described and defined, and the most common Forest Ecosystems can be listed.

The development of the map scale, diagnostic criteria, and legend design and presentation is intended to be practical for forest land managers. Some purists may argue that classification concepts and terms are being violated, but this is not intended to be an academic exercise - hopefully we will be excused. The Land System maps are intended for "non-site-specific" uses such as:

1. Regional planning and policy development,
2. General location of transportation routes,
3. Interface with hydrology, wildlife habitat and other resource interest planners, and
4. Narrowing the list of potential ecosystems for site classification.



Approximate Scale 1: 1,500,000

Figure 5. Ecoregions and Habitat (Forest) Subregions of the Sandilands pilot study area.

ECOREGION 4. Parkland

Subregion 4.83 Lower Red River Plain
4.84 Roseau River Plain

ECOREGION 7. Mid-Boreal Transition

Subregion 7.34 Lake Winnipeg Terrace
7.35 Red River Delta
7.36 Pine Ridge Plain
7.37 Caliento Plain

ECOREGION 21. Low Boreal

Subregion 21.01 Bedford Hills
21.02 Brokenhead River Plain
21.03 Lac Due Bonnet Plain
21.04 Whiteshell River Plain
21.05 Whitemouth Lake Lowland

The Land System maps are not intended to be used for:

1. Making site prescriptions, and
2. Detailed location of roads or other facilities.

Limitations of map scale and heterogeneity of many Land Systems dictate that decisions of a site-specific nature require site inspection and Forest Ecosystem classification. This approach avoids many of the limitations and concerns about map reliability, and reduces groundtruthing costs of mapping.

A soil inventory map is not required for an area prior to Land System mapping, although it is certainly useful to have. Manitoba Soil Survey Report No. 14 (Smith and Ehrlich 1964) covers the Sandilands pilot area.

3.4 LAND SYSTEMS OF THE PILOT AREA

The pilot project area is located in Townships 5, 6 and 7 of Range 10E, which extends from the Bedford Hills (Subregion 21.01) down onto the Brokenhead River Plain (Subregion 21.02) and the Whitemouth Lake Lowland (Subregion 21.05). The north end of the area is at the historic Dawson Cabin. The Whitemouth Lake Lowland consists entirely of bog and fen wetlands within the pilot area. No plots were located in this Subregion, and the wetland ecosystems are not described.

3.4.1 LAND SYSTEMS OF THE BEDFORD HILLS SUBREGION

The Bedford Hills Subregion (21.01) is a remnant upland glaciofluvial delta which formed at the front of a glacier. The gently sloping surface has been dissected by erosion channels, and the north edge of the upland has a steep escarpment. The surface has elevations of 1175 to 1275 feet (360 to 390 m) above sea level, with the lower boundary of the hills at approximately 1125 feet (340 m). Surficial materials are predominantly sands that fine downwards as is typical of a prograding delta. The sands are weakly duned in parts of the subregion.

Swales and depressions have restricted drainage and more mesic moisture regimes. Drainage of surface water is to the east or west from a central divide. The forest is jack pine-dominated Low Boreal that is highly disturbed from fires and harvesting, with few mature stands. Much of the area has been replanted to jack pine or red pine.

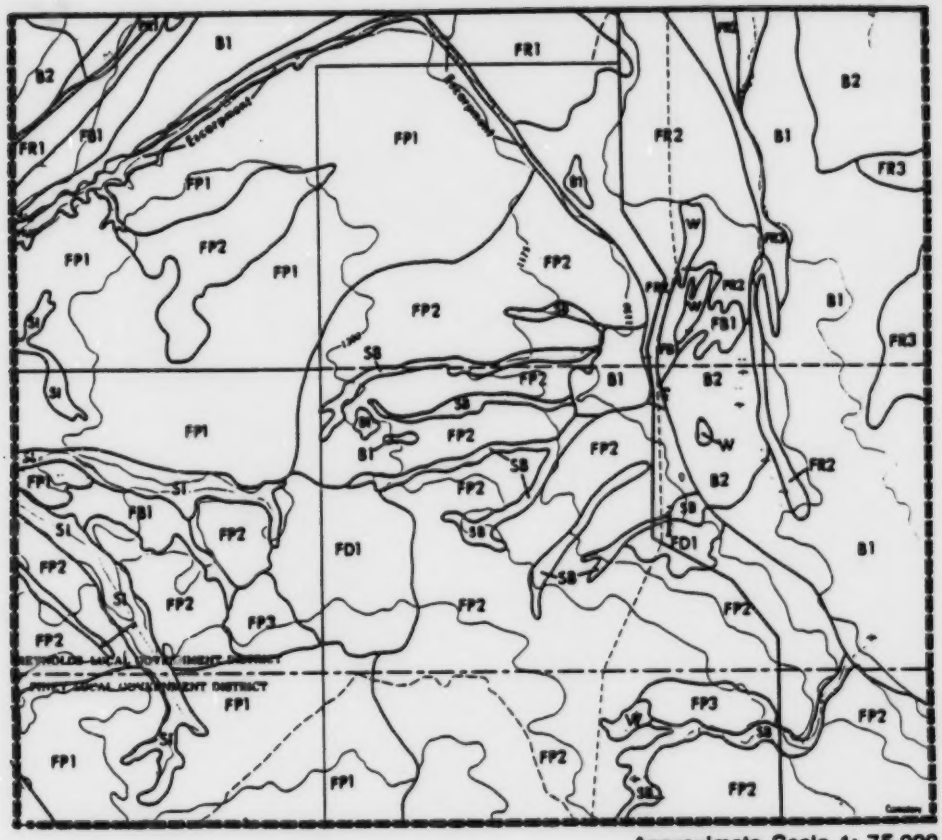
Part of the Land System Map and the legend have been reprinted (Figure 6) to illustrate the level of mapping detail and appearance of map labels and legend design. Land System 21.01 FP1 is a glaciofluvial plain (FP) in Subregion 21.01 (Bedford Hills). For ease of drafting the polygon on the map is simply labelled FP1 as the Region (21) and Subregion (21.01) are understood. All land areas labelled FP1 within a Subregion have similar surface form, geological materials, soils, hydrology and patterns of plant associations – and therefore the same dominant Forest Ecosystems.

There are frequently two to three common forest ecosystems in a Land System but the number varies with complexity of the Land System. Use of the alpha-numeric code allows identification of more than one Land System with the same landform (for example, there are three FP Land Systems) to recognize varying surface forms, materials and hydrology regimes. The higher number usually indicates a greater percentage of wetland (FP3 has more wet areas than FP1).

Diagnostic features for mapping the Land systems are those used to describe the Land Systems in the map legend;

- surface form and relief
- surficial geological materials
- hydrology (position in the watershed and wetness)
- dominant forest ecosystems

Many of these features can be interpreted from air photos, but some groundtruthing is required. In some areas there is a great deal of local relief, which is readily interpreted from air photos, and which relates well to landform, materials, hydrology and forest ecosystems. In other areas relief is much less and can be difficult to see on photos. Diagnostic criteria for mapping will have different relative value in different landscapes.



ECOREGION 21. LOW BOREAL

SUBREGION: 21.01 Bedford Hills (1150 to 1275 ft ASL)

LAND SYSTEMS	SURFACE FORM	MATERIALS	HYDROLOGY	FOREST ECOSYSTEMS
FP Glaciofluvial	Deltaic Plain			
21.01 FP1	high, flat-top plains, dissected, undulating mostly convex	fine sandy	rapid runoff and infiltration	LB2a
21.01 FP2	as FP1 but lower slopes and concave	fine sandy over loamy	runon, some ponding	LB2b
21.01 FP3	as FP2 with local seepage & ponding	fine sandy	runon, ponding, seepage	LB3 and unclassified
FD - Fluvial Dunes				
21.01 FD1	dunes ridges, mostly convex	fine sandy	rapid runoff, infiltration	LB1
FB - Fluvial - Bog Complex				
21.01 FB1	undulating plain with shallow bogs in swales	fine sandy, organic	local ponding and high W.T.	LB2b LB5
S - Stream Channels				
21.01 SI	incised stream channels with steep banks	mixed	rapid runoff	not classified
21.01 SB	channels infilled with bogs	organic	ponding	bogs

Figure 6. A portion of Subregion 21.01 Land Systems map and legend.

3.4.2 LAND SYSTEMS OF THE BROKENHEAD RIVER PLAIN

The portion of the Brokenhead River Plain (Subregion 21.02) that is within the pilot area is a low-relief deltaic plain that was built into a glacial lake. The land surface is channelled and weakly ridged, and the sediments range from sands to gravelly sands on ridges; and from sands to layered silts and clays in channels. The swales are generally occupied by shallow black spruce bogs, and the ridges and undulating plains are covered with jack pine forests. Extensive harvesting activities have removed most of the mature pine stands. Plantations of jack pine and red pine of varying age are extensive. In the northwest corner of the pilot area a very bouldery morainal landform with a sand blanket (FM Land System) is the dominant landform. This bouldery moraine is exposed to the north, along the trans-Canada highway.

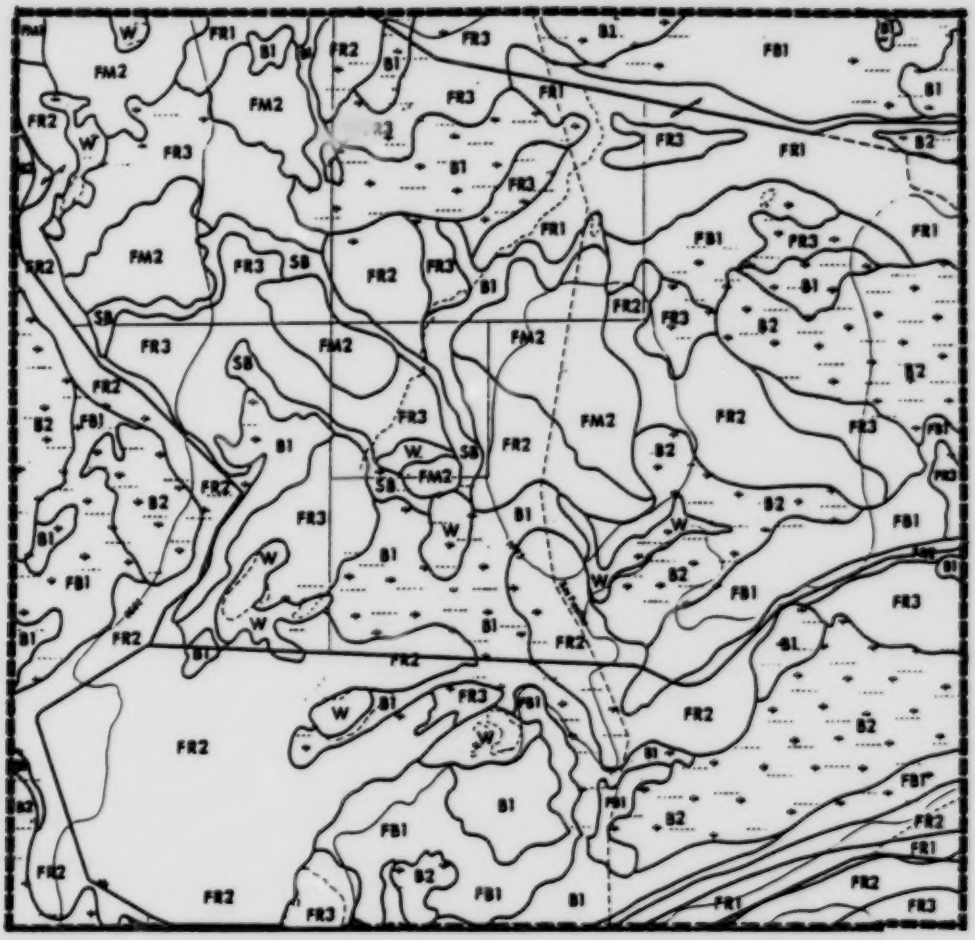
Part of the Land System Map and the legend for Subregion 21.02 is reproduced in Figure 7 to illustrate the mapping approach and presentation. The most extensive Land Systems are FR2 (glaciofluvial ridged) and the B1 and B2 (bog) units.

3.5 FOREST ECOSYSTEM CLASSIFICATION

3.5.1 Ecosystem Concepts

The Forest Ecosystem classification identifies and names a site (an area as small as 0.1 ha) by its plant association and soil series. The plant association and soil series are keyed to Ecoregion and Habitat Subregion (climate), and provide direct correlation to moisture and nutrient regimes, landform and surficial geological materials, vegetation successional stage and dynamics, and soil classification and chemical and physical properties. These are the variables that relate to site productivity and response of the ecosystem to silvicultural and harvesting treatments.

The forest ecosystem concept dates back to forest ecologists working in Russia and Germany in the 1920's and 1930's. The concepts were first applied in Western Canada by Krajina (1965) and his students in British Columbia; and by Mueller-Dombois in SE Manitoba (1965). More recent application of the concepts by Corns and Annas (1986) in western Alberta; by Kabzems, Kosowan and Harris (1986) in Saskatchewan, and by Jones et al. (1983) in the claybelt of Ontario have refined site classification in Canada.



Approximate Scale 1:75,000

SUBREGION: 21.02 Brokenhead River Plain (1025 to 1150 ft ASL)

LAND SYSTEMS	SURFACE FORM	MATERIALS	HYDROLOGY	FOREST ECOSYSTEMS
FM - Fluvial - Morainal				
21.02 FM1	undulating low relief, mostly convex	fine sandy blanket over coarse till, very bouldery	mostly runoff	LB2b, LB3
21.02 FM2	undulating, low ridge and swale	as FM1	runoff and runon - some ponding	LB3
FR - Fluvial-Ridged Outwash and Deltaic				
21.02 FR1	linear, ridged,	fine sandy,	rapid runoff	LB1

Figure 7. A portion of Subregion 21.02 Land Systems map and legend.

This approach allows a forest land manager to identify and name (i.e. classify) a site by its vegetation (trees and lower plants) and soil - and relate it to defined management methods with expected results. He can also communicate experience with this ecosystem to other land managers and researchers.

A Forest Ecosystem is defined as a "land" area with a particular plant association (or potential to support that plant association) and a particular soil series. This concept embraces all ecosystem parameters from the tree layer to approximately 2 m below the ground surface and laterally covering an area of about 0.1 to 2 or more hectares. The trees, shrubs, ground vegetation, landform, soils, and hydrology are considered.

A Plant Association is a recognizable group of associated plant species. Five common plant associations were recognized in the pilot area. One of these can be subdivided into two phases based on dominant species.

A Soil Series is a recognizable soil type on a particular geological material. A soil series is named after a local geographic feature for ease of reference. For example, the Sandilands soil series is a well drained, Eluviated Dystric Brunisol developed on sands that occurs in Ecoregions 20 and 21. The series name is therefore a simple code that identifies several soil parameters including: soil classification, geological materials, texture and mineralogy, moisture regime, nutrient regime, water infiltration rate, flooding hazard, presence of seasonally high water table levels, wind and water erosion risk and compaction hazard. Once learned, the soil series in an area are quite easy to recognize. Soil series names are exclusive to an Ecoregion. Current listings and descriptions of soil series by ecoregions should be obtained from Canada - Manitoba Soil Survey. Soil Survey staff are also responsible for correlation of soil names and concepts within the province.

Early, important contributions to ecological land classification in southeastern Manitoba include those of Mueller-Dombois (1965, 1963) and Ritchie (1961). Mueller-Dombois recognized 13 habitat types on a broad range of soil types and landforms. The five forest ecosystems described in the present study reflect the narrower range of soil and landforms examined. These five forest ecosystems, however, are analogous to forest habitats described by Mueller-Dombois as outlined below:

Forest Ecosystem		Habitat Type
LB1	JP/Arctostaphylos/Cladonia spp.	2. Dry Arctostaphylos - Cladonia type.
LB2a/LB2b	JP/Arctostaphylos JP/Arctostaphylos/Pleurozium	3. Fresh Arctostaphylos - Linnaea type.
LB3	WS-TA/Corylus/Aralia	9. Very fresh Cornus stolonifera - Corylus-Petasites palmatus type.
LB4	EC/Hylocomium	5. Very moist Feathermoss - Sphagnum type - Eastern cedar variant.
LB5	BS/Pleurozium	5. Very moist Feathermoss - Sphagnum type - black spruce variant.

3.5.2 FOREST ECOSYSTEMS OF THE PILOT AREA

The forest ecosystems recognized in the Sandilands pilot project area are listed in Table 7. The ecosystems encountered and sampled in the small pilot area represent only a portion of the total in the Low Boreal Ecoregion (Ecoregion 21). The following lists and descriptions are not exhaustive for the ecoregions; and represent mainly the fairly dry types that occur on sandy soils. A dichotomous key to the ecosystems is presented in Table 8.

Non-productive wetland ecosystems were excluded from this study.

Table 7. Forest Ecosystems of the Low Boreal (in Subregions 21.01 and 21.02 Pilot Area).

CODE	FOREST ECOSYSTEM (PLANT ASSOCIATION - SOIL SERIES)
LB1	JP/Arctostaphylos/Cladonia - Kettlehills
LB2a	JP/Arctostaphylos - Sandilands (Pine Ridge)
LB2b	JP/Arctostaphylos/Pleurozium - Sandilands (Pine Ridge)
LB3	WS-TA/Corylus/Aralia - Wintergreen (Pine Ridge)
LB4	EC/Hylocomium - Sundown
LB5	BS/Pleurozium - Rat River

JP	jack pine	EC	Eastern cedar
WS	white spruce	BS	black spruce
TA	trembling aspen		

Vegetation was used as the initial discriminator in the ecosystem classification. The Cornell Ecology Program TWINSPAN (Hill 1979a), or two-way indicator species analysis, was used to classify the vegetation into plant associations. TWINSPAN accomplishes this by classifying both plots and species using an ordination algorithm. A two-way table is produced which groups floristically similar plots and ecologically similar species. An advantage of TWINSPAN is it identifies key indicator species for each division point in the classification hierarchy. This was useful for constructing the key to the forest ecosystems (see Table 8).

The plant association was the basic unit in the vegetation classification. An association is an abstract vegetation unit characterized by the common occurrence of a group of associated plant species. In some cases facies were recognized, which are sub-divisions of the plant associations. Facies are characterized by the dominance of a certain (or several) species.

The Cornell Ecology Program DECORANA (Hill 1979b), an ordination procedure, was used to relate the vegetation classification to site and soil variables, (Figures 8 and 9) and refine the vegetation classification derived from TWINSPAN.

Table 8. Key to the Forest Ecosystems.

1a. Jack pine the dominant tree ..... key lead 2

1b. White spruce co-dominant with trembling aspen; moderately to well-developed shrub and herbs layers; *Corylus cornuta* is the characteristic shrub and *Aralia nudicaulis* is the characteristic herb. Wintergreen or Pine Ridge soils.

LB 3 WS-TA/Corylus/Aralia - Wintergreen (Pine Ridge)

1c. Eastern white cedar is the dominant tree; sparse understory with moderately-well developed moss layer. Sundown soils.

LB 4 EC/Hylocomium - Sundown

1d. Black spruce is the dominant tree; *Ledum groenlandicum* is the characteristic shrub; moss layer is well-developed with feathermosses dominant but *Sphagnum* spp. occasionally prominent. Rat River soils.

LB 5 BS/Pleurozium - Rat River

2a. *Cladonia* spp. often prominent in the understory; understory herb layer sparse; dune ridges. Kettlehills soils.

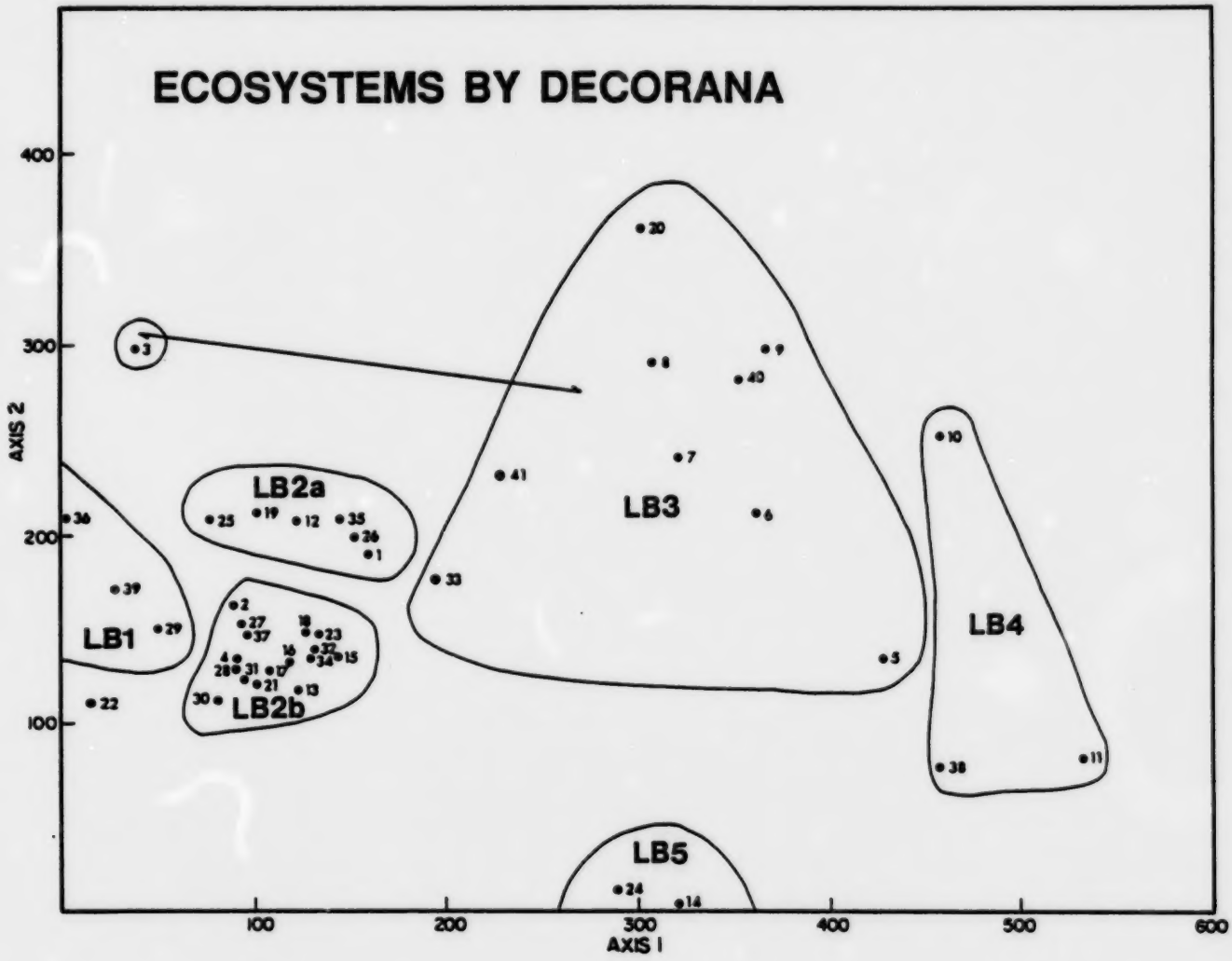
LB 1 JP/Arctostaphylos/Cladonia - Kettlehills

2b. Moss layer poorly developed; *Pleurozium schreberi* cover <10%; upper slope positions. Sandilands or Pine Ridge soils.

LB 2a JP/Arctostaphylos - Sandilands (Pine Ridge)

2c. Moss layer well developed; *Pleurozium schreberi* cover >50%; lower slope positions - slight depressions. Sandilands or Pine Ridge soils.

LB 2b JP/Arctostaphylos/Pleurozium - Sandilands (Pine Ridge)



DETRENDED CORRESPONDENCE ANALYSIS (DECORANA)

ECOSYSTEMS

LB1 JACK PINE/BEARBERRY/REINDEER LICHEN[1] - Kettlehills

LB2a JACK PINE/BEARBERRY - Sandlands (Pine Ridge)

LB2b JACK PINE/BEARBERRY/FEATHERMOSS - Sandlands (Pine Ridge)

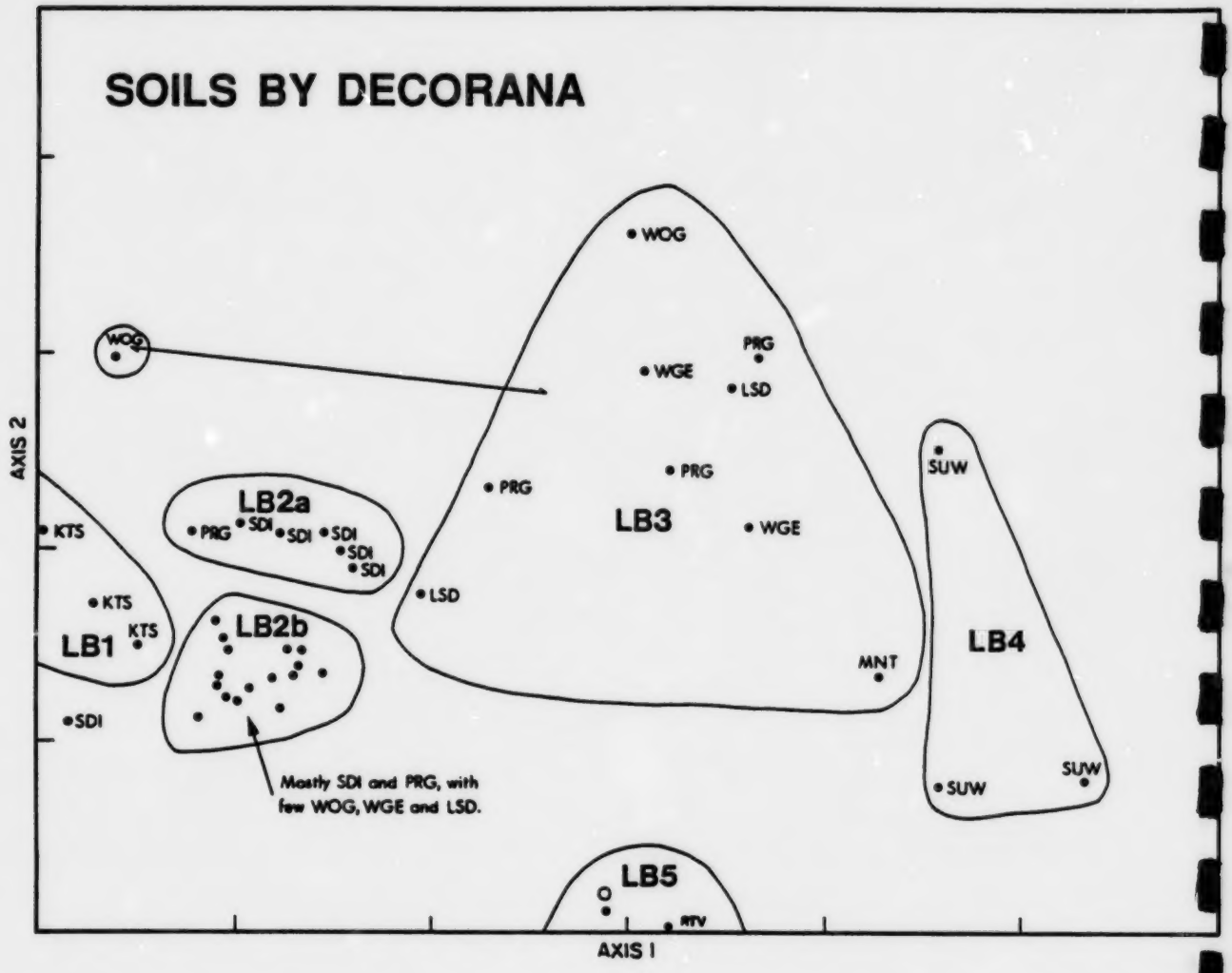
LB3 WHITE SPRUCE - TREMBLING ASPEN/HAZELNUT/SARSAPARILLA - Wintergreen (Pine Ridge)

LB4 EASTERN CEDAR/FEATHERMOSS - Sundown

LB5 BLACK SPRUCE/FEATHERMOSS - Rat River

[1] See Table 8 for proper names

Figure 8. The DECORANA ordination procedure was used to relate the vegetation classification to site and soil variables and develop Forest Ecosystem groupings (dots and numbers refer to sample plots – see Appendix III)



SOIL SERIES CODES

KTS	- Kettehills	SDI	- Sandilands
LSD	- Lonesand	SUW	- Sundown
MNT	- Malonton	WGE	- Wintergreen
O	- Organic (unnamed)	WOG	- Woodridge
PRG	- Pine Ridge	RTV	- Rat River

Figure 9. Displaying the soil names for plots on the DECORANA ordination illustrates how soils relate to the Forest Ecosystems.

Soil Survey Report No. 14 (Smith and Ehrlich 1964) provided reconnaissance scale (1:126,720) soil mapping of south-eastern Manitoba, including the pilot project area. Most of the soil series names used in this pilot project were established and described in Soil Survey Report No. 14. Some new soil names have been introduced since 1964, and the soil classification system has changed. Soil Survey Report No. 14 included estimates of productivity and reproduction of tree species for each soil series by Jameson and Cayford (1964). It did not relate productivity or forest management to forest ecosystems. A key to the soil names used in the pilot area is presented in Table 9, and soil series descriptions and analytical data from sampled profiles are presented in the Appendices.

Table 9. Key to the soils of the Low-Boreal.
- SUBREGIONS: 21.01 AND 21.02

DRAINAGE GROUP	SOIL SUBGROUP	RECENT FLUVIAL	GLACIOFLUVIAL FANS AND BEACH DEPOSITS AND DELTAS				
		fine sandy-loamy moderately-strongly calcareous	sandy,gravelly Fans, strongly calcareous	sandy, coarse loamy, weak to mod. cal. Fans	fine sand-sand, non calcareous beach ridges	duned fine sand	sandy-coarse loamy over till
Well	O.R	-	-	-	-	Kettlehills (KTS)	-
	E.DYB	-	-	-	Sandilands (SDI)	-	-
	O.GLE.EB	-	-	Pine Ridge (PRG)	-	-	-
	O.GL	-	Woodridge (WOG)	-	-	-	-
Imperfectly	GLE.DYB	-	-	-	Lonesand (LSD)		
	GLE.EB	-	-	Wintergreen (WGE)	-	-	-
	GLCLLR	Homestead (HMD)	-	-	-	-	-
	GL.GL	-	-	-	-	-	Calento (CLO)
Poorly	R.G	Novra (NOV)	Sundown (SUW)	-	Kerry (KRY)	-	-
	R.HG	-	-	Malonton (MNT)	-	-	-

		ORGANIC		
		0.4 to 1.6 m mesic fen peat over sand	mesic forest peat over sand	1.0 to 1.5 m fibric peat over 0.1 to 0.6 m mesic/sand
Very Poorly	T.M	Kiroro (KIC)	Rat River (RTV)	-
	TME.F	-	-	Sand River (SDV)

3.5.3 MOISTURE AND NUTRIENT REGIME CLASSIFICATION OF THE LOW BOREAL ECOSYSTEMS

The ecosystems can be arrayed on a moisture-nutrient gradient grid (Figure 10) to represent their relative ecological niches graphically, and to relate these to important environmental gradients.

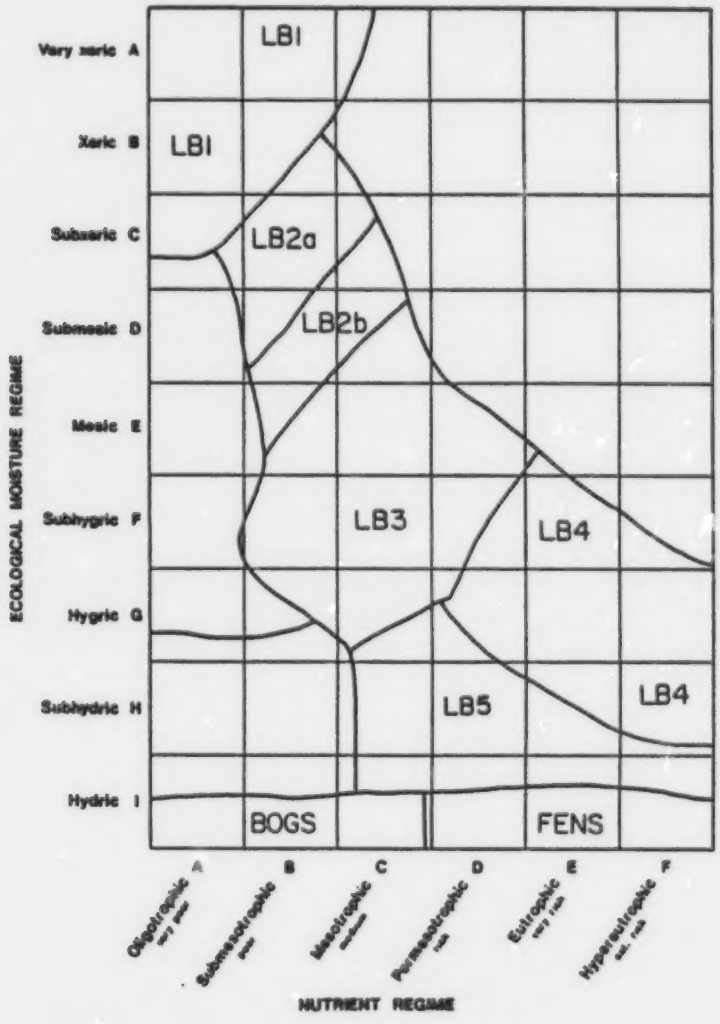


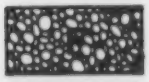
Figure 10. Moisture and nutrient regimes of the Low-Boreal Ecosystems.

3.6 FOREST ECOSYSTEM DESCRIPTIONS

Forest Ecosystem concepts and definitions were presented in Section 3.5.1 of this report. A dichotomous key to the ecosystems was presented in Table 8. Symbols appearing in the ecosystem diagrams on the following pages are presented below.

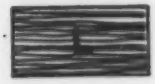
PARENT MATERIAL:

Eolian

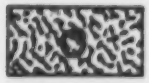


Recent fluvial

Glaciofluvial



Glaciolacustrine



Organic

Till (stony)

TREE SPECIES:

trembling aspen
(Populus tremuloides)

balsam poplar
(Populus balsamifera)

paper birch
(Betula papyrifera)

jack pine
(Pinus banksiana)

white spruce
(Picea glauca)

Eastern cedar
(Thuja occidentalis)

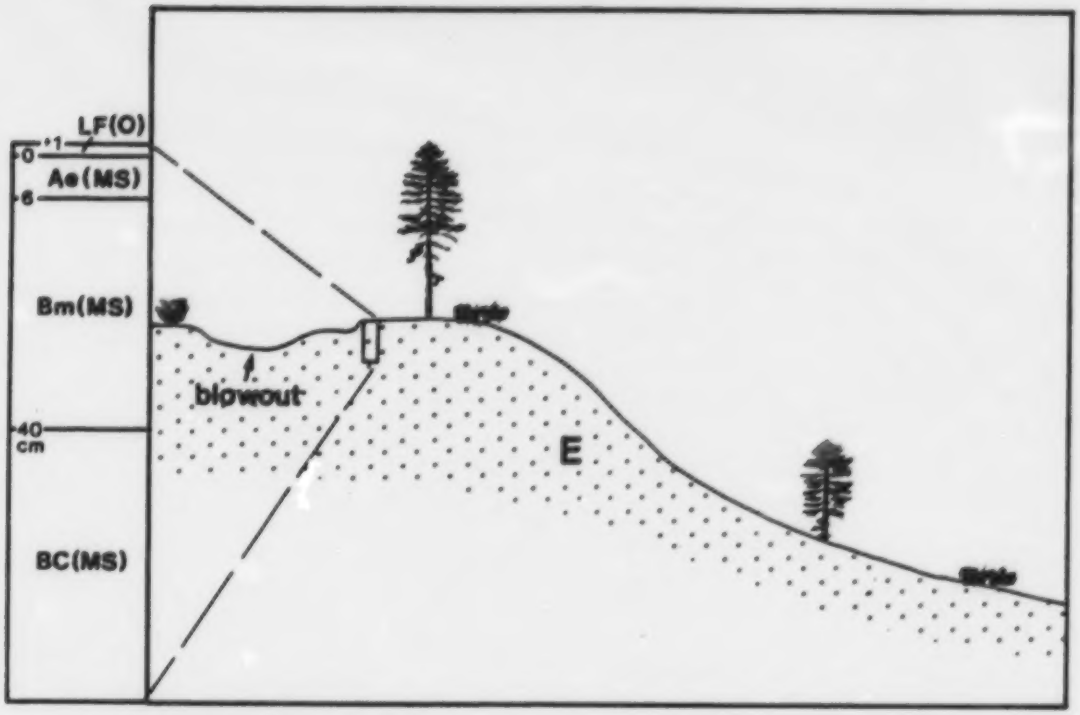
black spruce - bog
(Picea mariana)

LB 1

JP/Arctostaphylos/Cladonia - Kettlehills

(Jack pine/bearberry/lichen - Regosol or Orthic Dystric Brunisol/duned sand)

SLOPE:	5-10%	ASPECT:	any
ELEVATION:	320-360 m	RELIEF:	Low



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
Winter	SC*	Low	wind	Low	JP	Cont.

Note: Refer to Section 4 of report for guidelines and explanation of codes.

* Prevention of soil erosion by wind is a prime concern in planning harvesting of these ecosystems.

JP/Arctostaphylos/Cladonia - Kettlehills

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
Pinus banksiana (20)

Shrub Layer:
Arctostaphylos uva-ursi (12)
Vaccinium angustifolium (3)
Rosa acicularis (+) *
Amelanchier alnifolia (+)
Juniperus communis (+)

Herb Layer:
Maianthemum canadense (+)
Anemone quinquefolia (+)
Apocynum androsaemifolium (+)
Aster laevis (+)
Solidago decumbens (+)
Campanula rotundifolia (+)
Oryzopsis pungens (+)
Oryzopsis asperifolia (+)
Schizachne purpurascens (+)

Moss and Lichen Layer:
Pleurozium schreberi (20)
Dicranum spp. (7)
Cladonia rangiferina (7)
Cladonia mitis (3)
Polytrichum piliferum (3)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
340 m (320-366)

MEAN MOISTURE REGIME (RANGE):
Subxeric

SOIL pH in H_2O ($CaCl_2$):

	Range
LFH or Organic	5.7-5.8
A Horizon	5.8-5.9
B Horizon or Organic	5.9-6.1(4.8-4.9)
C Horizon or Organic	6.2-6.4

SOIL SUBGROUPS:
Dominant: Eluviated Dystric Brunisols
Associated:

* + indicates <1% cover

SOIL SERIES:
Dominant: Kettlehills
Associated:

MEAN SOIL DRAINAGE (RANGE): Rapid

MODAL LANDFORMS: Eolian

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
JP 16.5 m (16.2 - 16.8)

NUMBER OF PLOTS: 3

SUCCESSIONAL RELATIONSHIPS:
These are mature forests. Jack pine is the probable climax dominant.

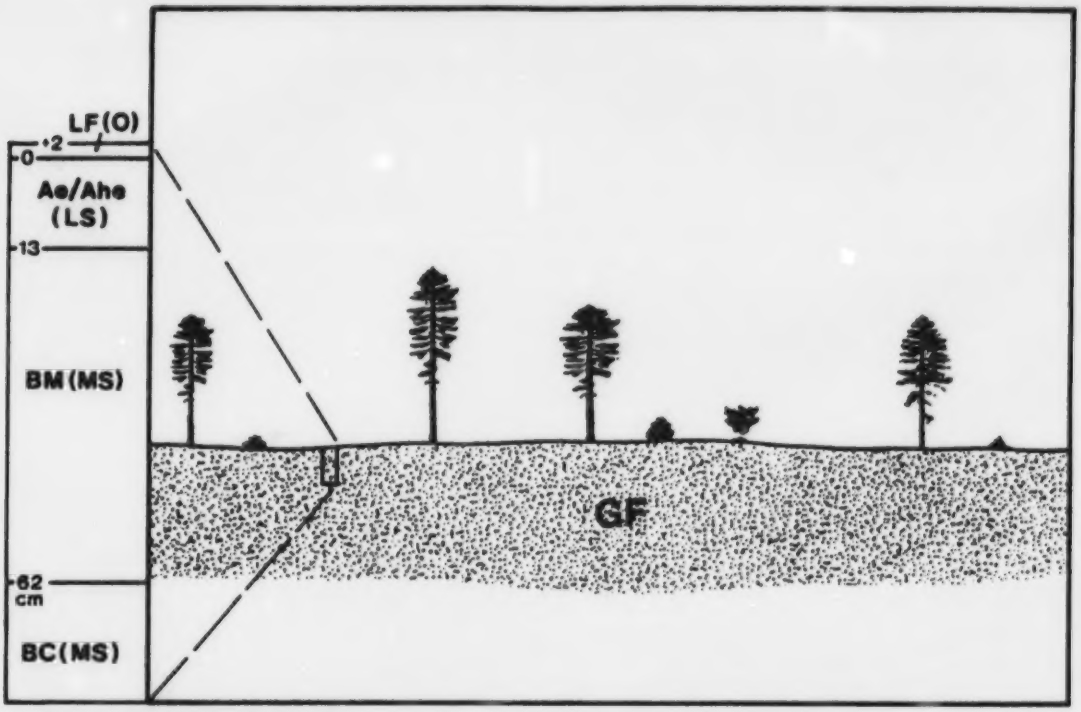
SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Pinus-Cladonia/Arctostaphylos Ecosystem of Kabzems et al. (1986) and to the Arctostaphylos-Cladonia type of Mueller-Dombois (1965).

LB 2a

JP/Arctostaphylos - Sandilands

(Jack pine/bearberry - Eluviated Dystric Brunisol/sandy glaciofluvial ridges)

SLOPE:	<2%	ASPECT:	-
ELEVATION:	320-365 m	RELIEF:	Low (convex)



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
All	CC,SC	Low	Low	Low	JP	Cont.

Note: Refer to Section 4 of report for guidelines and explanation of codes.

JP/Arctostaphylos - Sandilands

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
Pinus banksiana (20)

Shrub Layer:
Arctostaphylos uva-ursi (5)
Rosa acicularis (3)
Vaccinum angustifolium (3)
Amelanchier alnifolia (2)
Symphoricarpos albus (1)
Salix bebbiana (+)
Prunus virginiana (+)
Rubus idaeus (+)
Gaultheria procumbens (+)

Herb Layer:
Maianthemum canadense (6)
Oryzopsis asperifolia (5)
Cornus canadensis (1)
Lathyrus ochroleucus (1)
Schizachne purpurascens (1)
Fragaria virginiana (1)
Aralia nudicaulis (1)
Pteridium aquilinum (+) *
Apocynum androsaemifolium (+)
Anemone quinquefolia (+)
Campanula rotundifolia (+)
Aster laevis (+)
Linnaea borealis (+)
Lithospermum canescens (+)

Moss and Lichen Layer:
Pleurozium schreberi (8)
Dicranum spp. (1)
Cladonia rangiferina (+)
Polytrichum juniperinum (+)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
339 m (320-366)

MEAN MOISTURE REGIME (RANGE):
Subxeric (Subxeric - Submesic)

SOIL pH in H_2O ($CaCl_2$):

	Range
LFH or Organic	5.5-6.5
A Horizon or Organic	5.4-6.0
B Horizon or Organic	5.7-6.6(4.5-5.6)
C Horizon or Organic	6.4-7.9

SOIL SUBGROUPS:
Dominant: Eluviated Dystric Brunisol
Associated: Eluviated Eutric Brunisol

SOIL SERIES:
Dominant: Sandilands
Associated: Pine Ridge

MEAN SOIL DRAINAGE (RANGE):
Very Rapid (Very Rapid - Rapid)

MODAL LANDFORMS: Glacial Fluvial

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
JP 14.0 m (11.9 - 16.2)

NUMBER OF PLOTS: 6

SUCCESSIONAL RELATIONSHIPS:
These are mature forests. Jack pine is the probable climax dominant.

SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Pinus-Cladonia/Arctostaphylos Ecosystem described by Kabzems (1986).

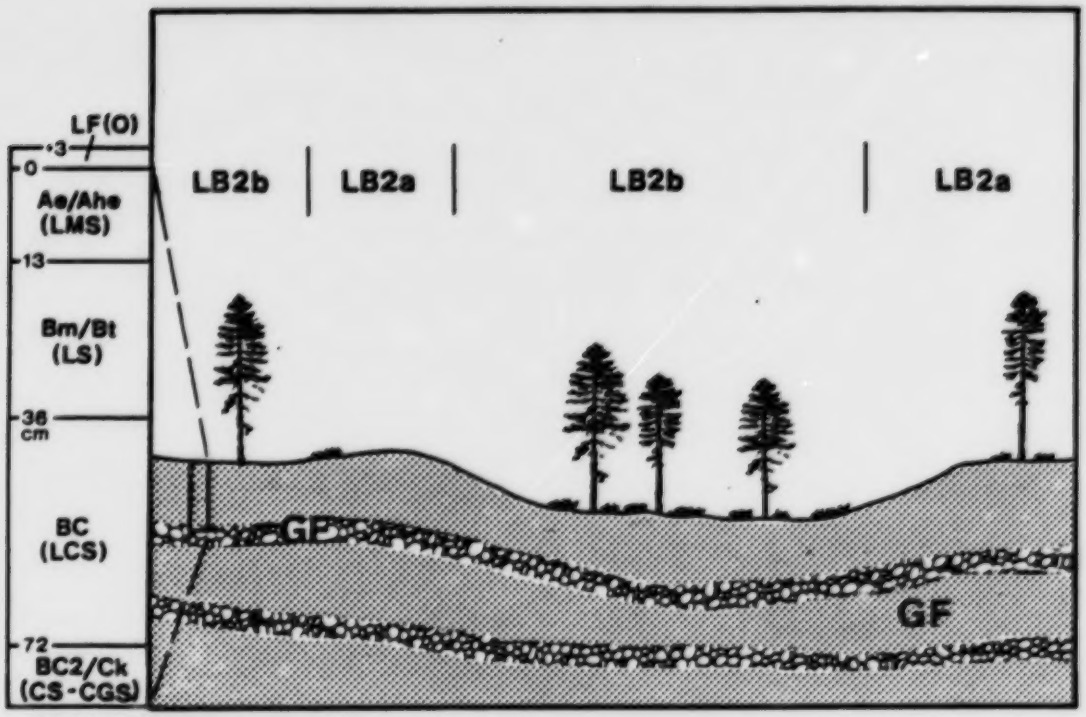
* + indicates <1% cover

LB 2b

JP/Arctostaphylos/Pleurozium - Sandlands (Pine Ridge)

(jack pine/bearberry/feathermoss - Eluviated Dystric Brunisol on sand)

SLOPE:	1-2% (depressional)	ASPECT:	-
ELEVATION:	320-360 m	RELIEF:	Low



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
All	CC,SC	Low	Low	Low	JP,RP	Cont.

Note: Refer to Section 4 of report for guidelines and explanation of codes.

JP/Arctostaphylos/Pleurozium - Sandilands (Pine Ridge)

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
- Pinus banksiana (21)

Shrub Layer:
- Arctostaphylos uva-ursi (7)
- Vaccinium angustifolium (3)
- Rosa acicularis (3)
- Amelanchier alnifolia (2)
- Symphoricarpos albus (1)
- Gaultheria procumbens (1)
- Prunus virginiana (+) *
- Lonicera dioica (+)
- Rubus idaeus (+)

Herb Layer:
- Maianthemum canadense (2)
- Oryzopsis asperifolia (2)
- Anemone quinquefolia (1)
- Fragaria virginiana (1)
- Lathyrus ochroleucus (1)
- Aster laevis (+)
- Lithospermum canescens (+)
- Linnaea borealis (+)
- Potentilla tridentata (+)
- Solidago hispida (+)
- Campanula rotundifolia (+)
- Schizachne purpurascens (+)
- Oryzopsis pungens (+)

Moss and Lichen Layer:
- Pleurozium schreberi (60)
- Cladonia rangiferina (5)
- Dicranum spp. (2)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
337 m (320-380)

MEAN MOISTURE REGIME (RANGE):
Submesic (Subxeric - Hygric)

SOIL pH in H_2O ($CaCl_2$):

	Range
LFH or Organic	4.9-6.3
A Horizon or Organic	5.7-6.4
B Horizon or Organic	5.9-7.9(4.8-6.5)
C Horizon	5.2-8.4

SOIL SUBGROUPS:
Dominant: Eluviated Dystric Brunisol
Associated: Gleyed Eluviated Eutric Brunisol, Eluviated Eutric Brunisol, Orthic Gray Luvisol

SOIL SERIES:
Dominant: Sandilands
Associated: Pine Ridge, Woodridge, Lonesand

MEAN SOIL DRAINAGE (RANGE):
Rapid (Very Rapid - Moderately Well)

MODAL LANDFORMS: Glacial Fluvial

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
JP 14.9 m (11.9 - 18.6)

NUMBER OF PLOTS: 15

SUCCESSIONAL RELATIONSHIPS:
These are mature forests. Jack pine is the probable climax dominant.

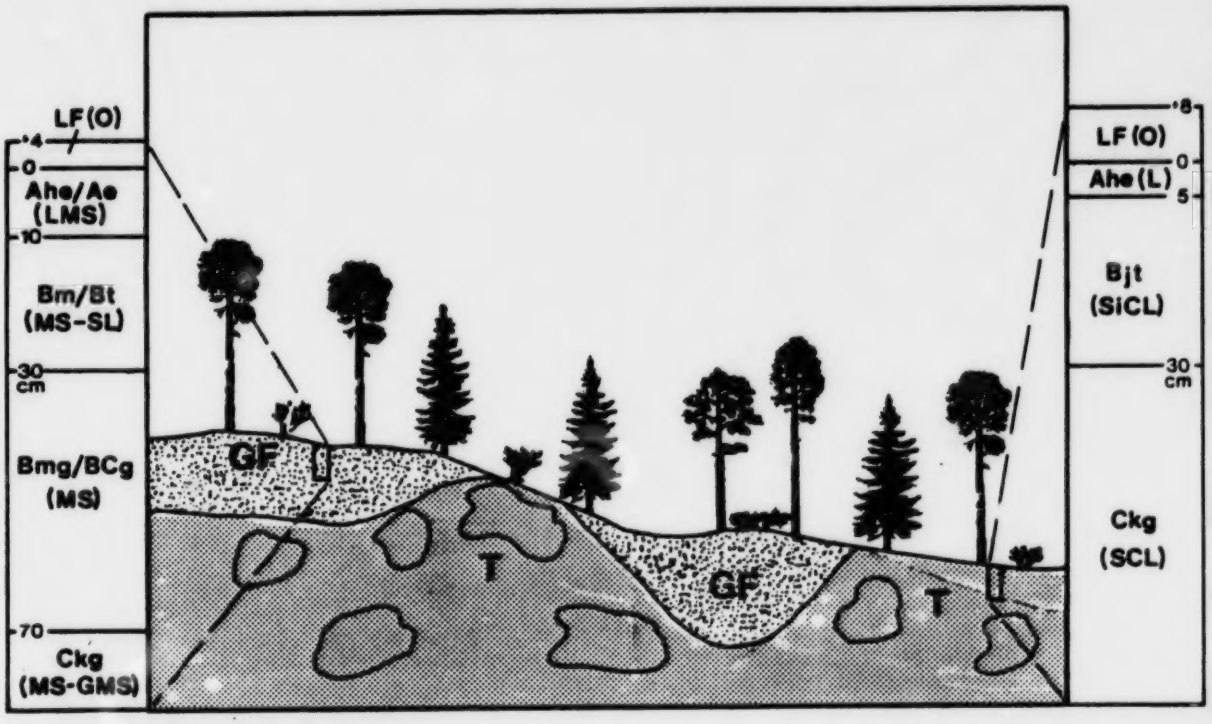
SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Pinus-Vaccinium vitis-idaea/Pleurozium Ecosystem of Kabzems (1986).

* + indicates <1% cover

LB 3

WS-TA/Corylus/Aralia - Wintergreen (Pine Ridge)
(white spruce-trembling aspen/hazelnut/sarsaparilla - gleyed Eutric Brunisol on sand)

SLOPE:	2 to 5%	ASPECT:	variable
ELEVATION:	310-380 m	RELIEF:	Low



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
Winter	CC	Mod.	High	Mod.	WS(TA)	C.BR(N)

Note: Refer to Section 4 of the report for guidelines and explanation of codes.

WS-TA/Corylus/Aralia - Wintergreen (Pine Ridge)

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
- Fraxinus pennsylvanica (1)
- Populus tremuloides (12)
- Picea glauca (3)
- Pinus banksiana (3)

Shrub Layer:
- Corylus cornuta (3)
- Rosa acicularis (3)
- Vaccinium angustifolium (2)
- Lonicera villosa (2)
- Abies balsamea (1)
- Amelanchier alnifolia (1)
- Betula pumila (1)
- Ledum groenlandicum (1)
- Populus tremuloides (1)
- Alnus rugosa (1)
- Lonicera dioica (1)

Herb Layer:
- Cornus canadensis (4)
- Pteridium aquilinum (4)
- Fragaria virginiana (2)
- Maianthemum canadense (1)
- Aralia nudicaulis (1)
- Schizachne purpurascens (1)
- Oryzopsis asperifolia (1)
- Lathyrus ochroleucus (+) *
- Linnaea borealis (+)
- Petasites palmatus (+)
- Aster ciliolatus (+)

Moss and Lichen Layer:
- Pleurozium schreberi (4)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
325 m (312-380)

MEAN MOISTURE REGIME (RANGE):
Subhygric (Subxeric - Hygric)

SOIL pH in H_2O ($CaCl_2$):

	Range
LFH or Organic	5.3-6.6
A Horizon or Organic	5.0-7.5
B Horizon or Organic	6.6-7.7(5.8-6.8)
C Horizon or Organic	8.2-8.6

SOIL SUBGROUPS:

Dominant:	Gleyed Eluviated Eutric Brunisol
Associated:	Eluviated Eutric Brunisol

SOIL SERIES:

Dominant:	Wintergreen/Pine Ridge
Associated:	Woodridge, Lonesand

MEAN SOIL DRAINAGE (RANGE):
Imperfectly (well to poorly)

MODAL LANDFORMS: Glacial Fluvial

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
WS 16.5 (11.3 - 21.6)

NUMBER OF PLOTS: 10

SUCCESSIONAL RELATIONSHIPS:
These are mature seral forests. White spruce is the probable climax dominant.

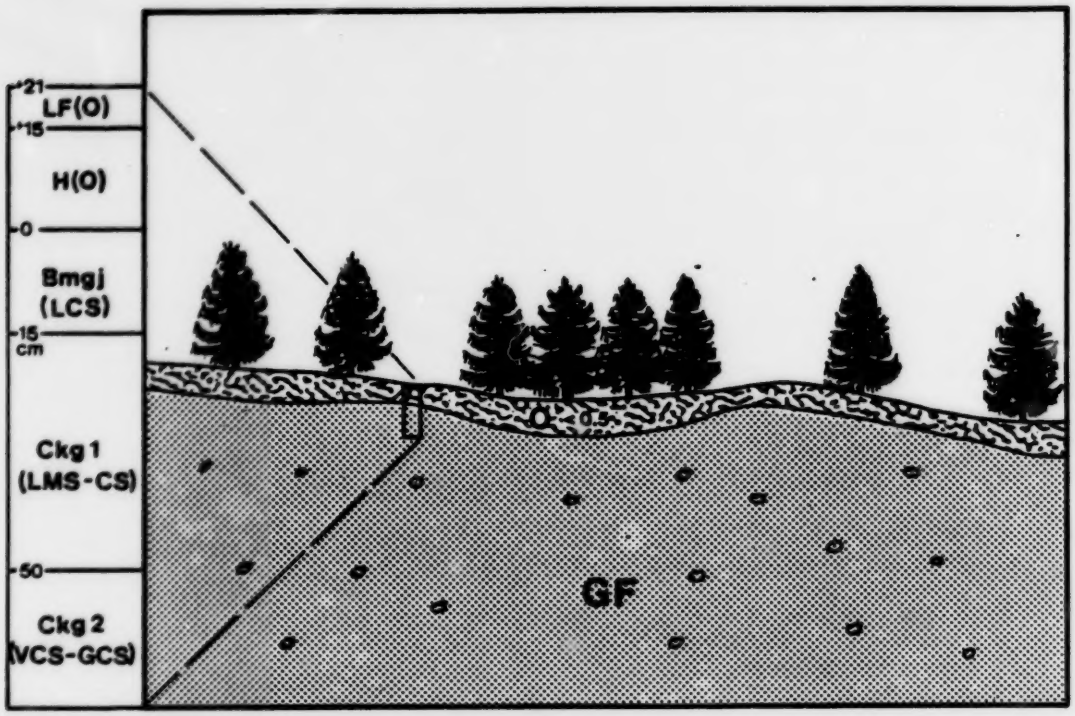
SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Cornus stolonifera-Petasites palmatus type of Mueller - Dombois (1965)

* + indicates <1% cover

LB 4

EC/Hylocomium - Sundown
(Eastern cedar/feathermoss - peaty Rego Gleysol)

SLOPE:	0 - 1%	ASPECT:	1
ELEVATION:	320-330 m	RELIEF:	Low (depressional)



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
Winter	SC	peaty	Low	-	EC, BS	Natural

Note: Refer to Section 4 of report for guidelines and explanation of codes.

EC/Hylocomium - Sundown

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
- Thuja occidentalis (38)
- Picea glauca (10)
- Populus tremuloides (7)
- Populus balsamifera (2)
- Abies balsamea (1)

Shrub Layer:
- Thuja occidentalis (4)
- Abies balsamea (3)
- Rosa acicularis (+) *
- Corylus cornuta (+)
- Cornus stolonifera (+)

Herb Layer:
- Aster ciliolatus (2)
- Linnaea borealis (2)
- Cornus canadensis (1)
- Rubus pubescens (1)
- Carex sp. (1)
- Equisetum scirpoides (1)
- Smilacina trifolia (1)
- Petasites palmatus (1)
- Smilacina stellata (+)
- Mitella nuda (+)
- Aralia nudicaulis (+)
- Caltha palustris (+)
- Equisetum pratense (+)
- Malanthemum canadense (+)

Moss and Lichen Layer:
- Hylocomium splendens (13)
- Climacium dendroides (2)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
325 m (320-335)

MEAN MOISTURE REGIME (RANGE):
Subhydric (Subhydric - Hygric)

SOIL pH in H_2O ($CaCl_2$):

	Range
LFH or Organic	7.0-7.9
A Horizon or Organic	-
B Horizon or Organic	7.7-8.4(6.7-7.0)
C Horizon	8.1-8.4

SOIL SUBGROUPS:
Dominant: peaty Rego Gleysol
Associated:

SOIL SERIES:
Dominant: Sundown

MEAN SOIL DRAINAGE (RANGE): Poorly

MODAL LANDFORMS: Glacial Fluvial

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
EC 18.0 (15.2 - 20.4)

NUMBER OF PLOTS: 3

SUCCESSIONAL RELATIONSHIPS:
These are mature forests. Eastern white cedar is the probable climax dominant.

SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Feathermoss - Sphagnum type, cedar type variant, of Mueller-Dombois (1965).

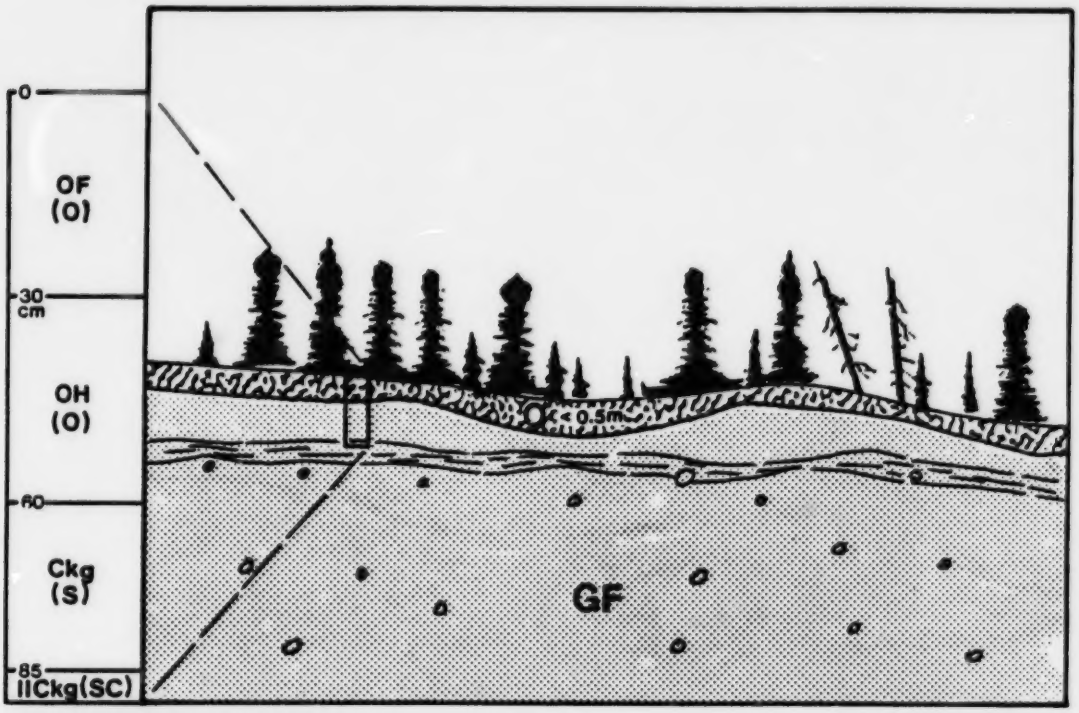
* + indicates <1% cover

LB 5

BS/Pleurozium - Rat River

(black spruce/feathermoss - shallow Organic over sand)

SLOPE:	0%	ASPECT:	-
ELEVATION:	310-330 m	RELIEF:	Level



MANAGEMENT RATINGS

Harvesting		Compaction Hazard	Erosion Hazard	Silviculture		
Season	Method			Site Prep.	Species	Method
Winter	SC	L (peat)	Low	High	BS	Cont.

Note: Refer to Section 4 of report for guidelines and explanation of codes.

BS/Pleurozium - Rat River

CHARACTERISTIC SPECIES (mean % cover):

Tree Layer:
- Picea mariana (45)
- Thuja occidentalis (3)

Shrub Layer:
- Thuja occidentalis (4)
- Ledum groenlandicum (2)
- Cornus stolonifera (1)
- Ribes triste (+)*
- Alnus rugosa (+)

Herb Layer:
- Cornus canadensis (3)
- Rubus pubescens (2)
- Linnaea borealis (2)
- Mitella nuda (1)
- Aralia nudicaulis (1)
- Smilacina trifolia (1)
- Aster ciliolatus (+)
- Carex gynocrates (+)
- Equisetum arvense (+)
- Equisetum scirpoides (+)

Moss and Lichen Layer:
- Pleurozium schreberi (37)
- Hylocomium splendens (20)
- Sphagnum spp. (12)

ENVIRONMENT:

MEAN ELEVATION (RANGE):
327 m

MEAN MOISTURE REGIME (RANGE):
Subhydric (Subhydric - Hydric)

SOIL pH in H_2O (CaCl2):

LFH or Organic	6.9
A Horizon or Organic	7.0
B Horizon or Organic	-
C Horizon or Organic	8.6

SOIL SUBGROUPS:
Dominant: Terric Mesisol

SOIL SERIES: Dominant: Rat River

MEAN SOIL DRAINAGE (RANGE):
Very poorly

MODAL LANDFORMS: Glacial Fluvial

PRODUCTIVITY:

MEAN SI AT 50 (RANGE):
BS 11.6 m (9.8 - 13.7)

NUMBER OF PLOTS: 2

SUCCESSIONAL RELATIONSHIPS:
These are mature seral forests. Eastern white cedar is the probable climax dominant.

SIMILAR FOREST ECOSYSTEMS:
This ecosystem is similar to the Picea mariana -Pleurozium/Hylocomium Ecosystem of Kabzems et al. (1986) and to the Feathermoss - Sphagnum type of Mueller-Dombois (1965).

* + indicates <1% cover

4. FOREST MANAGEMENT AND PRODUCTIVITY

Ratings of the performance of Forest Ecosystems under various silvicultural and harvesting management systems (i.e. management interpretations), and of the productivity of natural systems are described in this Section.

4.1 MANAGEMENT INTERPRETATIONS

The ratings of performance under different management inputs are necessarily estimates - since documented responses are not available at this time. Guidelines for the estimates are presented in the following tables - to allow review and criticism of the approach and the selected class limits. This is a pilot project - response and feedback are required.

4.1.1 INTERPRETATION GUIDELINES

Table 10. Optimum season of harvest.

Internal drainage	Texture of B horizon[1]	Optimum season of harvest
Rapidly to moderately well	Sandy	All
Rapidly to moderately well	Textures finer than sandy	Winter only[2]
Imperfectly to very poorly	All	Winter only

[1] Texture symbols are as follows: L = loam(y) and S = sand(y)

[2] The main concern on well-drained, fine- to medium-textured soils is susceptibility to soil compaction rather than ability to support heavy equipment.

COMMENTS:

Optimum season of harvest is either winter, when soils are frozen, or all season. All sites should be avoided during spring melt and after heavy rains. Choice of season relates to soil wetness and texture of the B horizon which determine trafficability and compaction hazard.

For discussion: should the following also be considered?
- proximity to streams or lakes
- thickness of organic layer
- other factors

Table 11. Site preparation intensity.

Internal drainage	Vegetational competition	Slash abundance	Organic layer thickness (cm)[1]	Intensity[2]
Rapidly to moderately well	Low	L-M	<10	L
			10 - 15	M
			15 - 30	H
		H	>30	H
	Moderate	L-M	<15	M
		H	15 - 30	H
			>30	H
	Imperfectly to very poorly	L-M	<15	M
			15 - 30	H
	High	L-H	<30	H
		L-H	>30	H

[1] Where the organic layer is >30 cm, seedlings should be planted in moist, unvegetated organic matter on the side of the prepared trench.
[2] L = low, M = moderate, and H = high.

COMMENTS:

Site preparation intensity indicates the degree of surface scarification required, which depends on vegetation competition hazard, seed supply and reforestation method. Several options are usually available.

For discussion: should we also consider:
- machine factors (slope, stoniness, trafficability)
- soil texture (stickiness, water holding capacity
- erosion hazard

The following discussion from Corns and Annas (1986) describes preparation intensity and equipment.

Low Intensity

These sites are generally moderately well to rapidly drained and have shallow (less than 10 cm) soil organic layers, minimal plant competition problems, and low to moderate slash abundance. Satisfactory lodgepole pine regeneration on many sites having a good cone supply may be achieved with minimal site preparation if the slash and cones are well distributed. Methods of low intensity site preparation include the following:

Screefing (mattock, boot, spade): These manual scarification methods may be appropriate when planting bare-root stock on topographically irregular sites, sites that are inaccessible to large machinery, sites where soil compaction may be a problem, small areas where it is expensive to move large machinery, and sites where plant competition (especially reedgrass (Calamagrostis canadensis) is well established and when more-severe site preparation may further stimulate competition.

Table 11. Site preparation intensity (cont'd)

Anchor-chain drags: This method gives satisfactory results on a wide variety of pine sites, and scarification intensity and degree of coverage can be regulated by the number and length of the drags. Caution should be taken to minimize soil compaction on sites with fine soil texture or weak structure.

Toothed scarifier blade: The main concern should be to redistribute slash (cones) if necessary, as the shallow organic layer should not pose a significant impediment to rooting seedlings. Soil compaction may be significant on fine-textured soils or on those with weak structure.

Moderate Intensity

These sites are moderately well to imperfectly drained, have moderately deep (10-15 cm) soil organic layers, moderate to high plant competition ratings, and low to moderate slash abundance. Methods of moderate intensity site preparation include the following:

Shark-fin barrels: This equipment does a satisfactory job on level to gently sloping moist sites with moderate slash abundance and moderately deep organic layers. Degree of scarification can be regulated by the amount of fluid put in the drums as well as the number and length of the attached anchor-chain drags.

Toothed scarifier blade: This equipment on a large tractor (e.g., Caterpillar D6 and larger) is capable of spreading large amounts of slash and penetrating deep organic layers.

Bracke scarifier: This machine may provide good results on mesic sites and sites where plant competition is a problem. It leaves planting sites with a wide range of moisture regimes from the top of the overturned soil and organic layer to the bottom of the scalp.

High Intensity

These sites are poorly to imperfectly drained, with deep (15-30 cm) organic horizons, generally high plant competition rating, and low to high slash abundance. Methods of severe intensity site preparation include the following:

Marttini plow: This rear-mounted plow is capable of exposing mineral soil on wet sites with deep organic layers. Compared with alternative equipment such as the C & S ripper plow, the Marttini plow's large size and weight make it more difficult to maneuver and increase the chances of getting stuck, resulting in soil damage. Chances of subsoil glazing and compaction are greater with the Marttini plow than with some other severe methods (e.g. ripper plow), although toothed edges on the plow will reduce glazing. Flooding of the furrow is a problem on very wet sites. Furrows should run perpendicular to slope contours to maximize soil drainage, but erosion can be a concern, particularly during spring runoff and on fine-textured till and lacustrine materials. The Marttini is best suited to very gentle short slopes on less erodible materials (e.g., some tills).

Ripper plow (Craig-Simpson, C & S): This plow and adaptations of it have proved to be versatile machines for site preparation on wet sites, because it is more maneuverable than the large Marttini. The ripper plow is often used in conjunction with a brush rake or toothed scarifier blade to move heavy slash, particularly the currently unutilitized hardwoods, into windrows.

Table 11. Site preparation intensity (concluded)

Brush rake: This multitoothed bulldozer blade can effectively increase the receptive area for regeneration by putting heavy slash and unutilized hardwoods into windrows and by removing excess organic matter from the soil surface. As with other treatments that involve use of heavy equipment, soil compaction is likely to result.

Toothed scarifier blade: This blade can penetrate thick organic layers and spread heavy slash loads.

Cazes and Heppner plow (C & H): This wide, front-mounted V-blade can effectively remove virtually all vegetational competition (including well-established young trees) plus soil organic and surface mineral horizons. The resulting denuded surface can be very susceptible to erosion on slopes, especially where soils are fine-textured. Soil compaction and glazing of the subsoil could also be anticipated on fine-textured soils. The C & H plow is not advised for use on fine-textured soils or soils with excess water. The debris plied on both sides of the plow prevents lateral water movement at the soil surface and can cause flooding on the prepared seedbed. The edges of the bladed strips are usually the best sites for planting. In these situations, organic matter and nutrients are likely to be more abundant and susceptibility to drought and frost heave is likely to be less. Less-severe scarification methods are probably adequate preparation for planting on most sites, and the C & H plow should be restricted to areas of well-drained, medium- to coarse-textured, stable soils where stand conversion (e.g. aspen to lodgepole pine) is being attempted.

Table 12. Soil compaction hazard (adapted from Boyer 1979).

Coarse Texture[1]	L & F (humus) fragments	thickness	Character of coarse Structure	fragments	Rating[2]
loamy, fine loamy	<35%	<5 cm	Strong	All	M
			Moderate and weak	All	M
coarse loamy		>5 cm	Moderate and weak	All	H
			Strong	All	M
	30-60%	<5 cm	Moderate and weak	Rounded	M
				Angular	M
			Strong	All	L
	>60%	Any	All	All	L
sandy	Any	Any	All	All	L
	>35%	Any	All	All	L
clayey	<35%	<5 cm	Strong	All	L
			Moderate and weak	All	M
		>5 cm	Moderate and weak	All	M
			Strong	All	L

[1] Texture symbols are as follows: L = loam(y), Si = silt(y), C = clay, S = sand(y), and vf = very fine.

[2] L = low, M = moderate, and H = high. In making a rating, consider the characteristics of the litter and upper 30 cm of mineral horizon(s). A wet or moist condition is assumed. The horizon that gives the poorest rating is used.

COMMENTS:

Soil compaction can result in poor root growth and seedling establishment. This is most important at landings and other high traffic areas. This information can be used to help choose landing sites.

Table 13. Soil water erosion hazard.

Parent material	Texture B horizon[1]	Slope (%)	Hazard[2]
Till	loamy to sandy	<10	L
Till	fine loamy	<10	M
Till	loamy to sandy	10 - 15	M
Till	Very stony variable texture	15 - 60	M
Eolian	sandy	0+	M[3]
Glaciolacustrine	clayey	0+	H
Glaciofluvial, fluvial	loamy to sandy	0+ (especially Gleysols)	H
Till	clayey to fine loamy	>10	H
Till	loamy to sandy	>15	H

[1] Textural groups are as follows: fine-sandy clay, silty clay, heavy clay; moderately fine-clay loam, sandy clay loam, silty clay loam; medium-very fine sandy loam, loam, silty loam, silt; moderately coarse-sandy loams; coarse-sands, loamy sand.

[2] L = low, M = moderate, H = high. Ratings assume unvegetated surface. Dense vegetation cover will reduce hazard by at least one class.

[3] Duned eolian (wind-deposited) sands have high wind erosion hazard if surface cover is removed.

COMMENTS:

Water erosion hazard has been of limited concern in Manitoba forest operations. Potential is greater in high relief areas like the Bedford Ridge than in most areas, especially where clays are present on fairly steep slopes.

Wind erosion hazard in a concern on fine sandy loam textured soils, especially old sand dune landforms.

Table 14. Reforestation method on cut blocks.

Site conditions	Seed availability[1]	Jack pine	White spruce	Black spruce	Aspen
Soil moderately well to rapidly drained, organic layer generally <10 cm, vegetation competition not usually a problem	Abundant	Natural	Natural	Natural	Natural, root suckers
	Sparse	Container, direct seed[2]	Container, direct seed	Container, direct seed	Natural, root suckers
Soil imperfectly or more poorly drained, organic layer generally >10 cm, vegetation competition often a problem	Abundant	Container, bare-root, natural	Container, bare-root, natural	Container, natural	N/A[3]
	Sparse	Bare-root, container	Bare-root, container	Container	N/A

[1] Seed abundance is a function of slash and cone abundance plus proximity to adjacent seed-producing trees (especially important for spruce).

[2] Direct seeding will have best results when 40-60% mineral soil is exposed and soil is near field capacity.

[3] N/A = Not applicable. Aspen does not do well under these conditions.

COMMENTS:

The following discussion of reforestation methods is from Corns and Annas (1986).

Reforestation method here refers to the means by which satisfactory tree stocking is achieved on logged areas. The alternatives are natural seeding from slash or adjacent trees, root suckers (aspen), manual or direct seeding, container planting stock, and bare-root planting stock. The situations applicable to the various options are discussed below:

Natural

Pine: Sites with good cone crops, soils moderately to well or better drained, and organic layers less than 10 cm thick can generally be adequately restocked without additional planting. A light scarification is usually necessary to bring cones into contact with mineral soil.

Spruce: Satisfactory natural spruce stocking is likely to be attained only on sites with a continuing seed source, such as on small patch or strip cuts or where seed trees are left, and will be favoured where mineral soil is exposed and moisture is neither limited nor in excess.

Aspen: Satisfactory natural aspen stocking is usually achieved by root suckering from cut trees adjacent to uncut trees, without additional silvicultural input.

Table 14. Reforestation method on cut blocks (concluded)

Balsam and subalpine fir: These generally regenerate satisfactorily naturally under the canopy of other trees as well as in the open, particularly at higher elevations.

Direct Seeding

Satisfactory stocking results from direct seeding can be expected only where there is a large amount of exposed mineral soil (40-60%), minimal vegetational competition, and enough moisture to ensure germination and seedling establishment. Timing of the seeding operation is crucial. It should be done on spring snow cover after a light snowfall (Hellum 1974). Success of direct seeding operations has been variable and generally not encouraging.

Planting Containerized Stock

In general, seedling survival and early growth is influenced by the volume available for root growth and development. Consequently, a seedling grown in a unit such as a Spencer-Lemaire 55 cm^3 container should generally outperform those in the standard 40 cm3 container, particularly on sites with potential vegetation competition or snowshoe hare damage problems. It appears that on droughty sites containerized stock may be more desirable than the larger, more water-demanding bare-root stock.

Bare-root Stock

Bare-root planting stock can generally gain an advantage over container stock, especially on sites with abundant vegetational competition because of its greater size, age, and more sturdy condition. This is more true with white spruce than with pine, due to the slow initial growth of the spruce.

4.1.2 Forest Ecosystem Management Interpretations

The management interpretations by ecosystem were developed using the interpretation guidelines and from conversation with field foresters with experience in the region. The results of operational trials published by Cayford (1968) and estimates of productivity by Jameson and Cayford (1964) were also used in developing the management recommendations.

Ecosystem LB1 - Jack pine/Arctostaphylos/Lichen - Kettlehills soils on dunes.

This ecosystem is a sensitive landscape due to the risk of severe wind erosion and development of blowouts if the surface cover is removed. The soils and the litter layer dry very rapidly, resulting in high fire hazard in those ecosystems.

Harvesting - Tree cover is best left undisturbed on the most sensitive sites - the dune crests and slopes. If salvaging after fire, minimum surface disturbance is desired (winter operation). Use selective cutting or keep cut blocks small to reduce wind fetch.

Site treatment - Minimum surface disturbance is desired to minimize wind erosion hazard. Competition is low or non-existent. On bare sites or blowouts spreading slash and walking it in with a tracked vehicle and light trenching or ridging, or gouging with a Bracke scarifier, will help to create surface roughness to reduce wind erosion. Small basins or trenches will also trap some moisture and serve as planting sites.

Species/Stock - Jack pine is the preferred species due to drought tolerance. Two-year old stock in large containers with a high root to shoot ratio is preferred due to the harsh site conditions. Rapid cover is desired. Planting should be done during times with greatest probability of rain as the soils have very low water holding capacity. No guidelines are available for recommended planting spacing.

Ecosystem LB2a - **Jack pine/Arctostaphylos - Sandilands soils or low sand ridges.**

This ecosystem is primarily found on low ridges of very sandy soils. The sites are not as dry as the LB1 ecosystems, and are not as prone to wind erosion - but are still droughty. They also have high fire hazard rating due to rapid drying.

Harvesting - can be done in summer or winter due to sandy soils, good drainage, and low compaction hazard. Cut blocks should be kept small to minimize wind erosion risk and drying effect due to wind. Selective cutting may be a more effective way to reduce the drying effect.

Site Preparation - past practice has been to chop the slash and trench quite deeply, and plant in the trench. This has the effect of reducing competition but it removes almost all of the nutrients from the vicinity of the seedling. Nutrients are tied up in the litter and slash and the surface few centimetres of the soil - which are left mounded between the trenches. A Bracke scarifier, which makes gouges rather than trenches, may be more effective in leaving nutrient pools closer to the seedling.

Species/Stock - Jack pine is the preferred species, but Red pine also appears to do reasonably well on these sites. Two-year old stock in large containers is preferred. Planting success will be greatest during wet spring conditions – rain is needed as the soils are very droughty. Optimal spacing is unknown at this time.

Ecosystem LB2b - **Jack pine/Arctostaphylos/Pleurozium - Sandilands or Pine Ridge soils on lower slopes or swales**

This ecosystem is located on lower slopes and swales where the soils are still very sandy but there is a little more moisture available. The nutrient regime is richer than LB1 or LB2a. The sites dry more slowly than LB1 or LB2a types, resulting in lower fire hazard ratings.

Harvesting - Harvesting can be done in all seasons, by clear-cut, strip-cutting or selective cutting. Compaction hazard and erosion hazard are low, but there will be some associated wet swales in areas with predominantly LB2b sites.

Site Treatment - Past practice has been to chop the slash; trench; and plant in the trench. Duff layers are somewhat thicker than in the LB2a ecosystem, and competition will be greater.

Species/Stock - Jack pine or Red pine are the preferred species. Container stock (large containers) are recommended but large bareroot stock may also be successful.

Ecosystem LB3 - White spruce - trembling aspen/Corylus/Aralia - Wintergreen or Pine Ridge soils

This ecosystem has mesic to subhygric moisture regimes and mesotrophic to even more rich nutrient regimes. Perched water tables are common, as are wetter ponding areas.

Harvesting - Winter operations are recommended due to frequently wet or moist soil conditions and moderate compaction hazard. Clear cutting is preferred. Stands are usually mixed softwood-hardwood.

Site Treatment - Site treatment varies with present species cover and preferred species for management. Slash may be moderate or heavy, depending on utilization of the hardwoods. Moderate intensity scarifying or trenching is required for white spruce site preparation. Competition can be expected to be strong.

Species/Stock - White spruce is the recommended species to plant. Container or bareroot stock can be used. Some natural regeneration may be present. Some sites could be managed for aspen, relying on natural regeneration.

Ecosystem LB4 - **Eastern cedar/Hylocomium - Sundown soils in poorly drained areas at edges of bogs**

These wet sites have a fairly thick peaty layer over sand or bouldery sands or till. The water table is high most or all of the year, and the nutrient regime is very rich.

Harvesting - Most utilization of these types is for posts, and harvesting is best done in winter due to wet, peaty soils.

Site Treatment - No site treatment is usually done at these sites -- the cedar is regenerating under the canopy. The sites could be converted to black spruce or white spruce with drainage and site preparation.

Species - Eastern cedar by natural regeneration (or black spruce or white spruce by planting bareroot stock).

Ecosystem LB5 - **Black spruce, Pleurozium - Rat River soils on thin peat layers over sands**

These very wet shallow bog sites have a water table very near the surface all year, but have much higher nutrient regimes than expected for "classical bogs". Peat thickness varies, getting thicker in the middle of old channels and shallower along the edges.

Harvesting - Wetness restricts harvesting to the winter season when soils are frozen. The peat layers have very low bearing capacity.

Site Treatments - These sites are candidates for improvement by drainage -- if a drain outlet or "sink" can be found. The drained sites would be suitable for white spruce or black spruce. High intensity site treatment is needed due to thick peat layers, if the sites are not drained. Trenches in undrained sites will be full of water and not suitable for planting, but mounds or ridges may be suitable.

Species/Stock - Black Spruce (container stock) on undrained sites. White Spruce on drained sites.

4.2 SITE/PRODUCTIVITY RELATIONSHIPS

4.2.1 OVERALL RESULTS

Table 15 summarizes basic statistics for each continuous variable while Table 16 summarizes the correlations between the productivity measures and the independent variables. The latter table shows that no variables are significantly related to SI and only the pH of the A horizon and the pH of the B horizon are significantly related to MAI. It is also worth noting that neither pH variable accounts for more than 30% of the total variation in MAI[2].

Table 15. Summary statistics for continuous variables.

	Cases	Mean	Std. dev.
Site Index	37	15.54	2.93
Mean Annual Increment	35	1.78	1.15
Elevation	41	333.98	19.44
Breast Height Age	38	61.03	31.10
Total Age	36	68.54	23.06
Coniferous Volume	40	110.55	94.98
Deciduous Volume	40	26.72	79.30
Total Volume	40	137.27	108.82
Coarse Fragments in A	1	5.00	-
Coarse fragments in B	19	9.68	11.37
Coarse Fragments in C	20	16.55	11.02
Humus Depth	41	6.09	10.77
pH of Humus	22	6.07	0.73
pH of A	23	6.19	0.76
pH of B	24	6.49	0.75
pH of C	16	7.92	0.94
Solum Depth	40	44.58	16.29

[2] The proportion of the variation accounted for is equal to the square of the correlation coefficient. Therefore the proportions accounted for by PHA and PHB are 24.7% and 28.2% respectively.

Table 16. Correlations (r-values) of continuous variables with SI and MAI.

	SI		MAI	
	r	n	r	n
Elevation	-0.111	37	-0.324	35
Fragments of A	-	1	-	1
Fragments of B	-0.076	16	-0.020	16
Fragments of C	-0.329	18	-0.320	17
Humus Depth	-0.247	37	-0.047	35
pH of Humus	0.151	19	0.307	18
pH of A	-0.055	19	0.497*	19
pH of B	0.386	20	0.532*	20
pH of C	0.332	13	-0.020	12
Solum Depth	-0.270	36	0.042	35

* significant at 0.05 (2-tailed)

4.2.2 DISCRETE VARIABLES

Table 17 shows that MAI is not significantly related to any of the discrete variables while SI is only significantly related to 4 variables: drainage class, moisture regime, soil subgroup and soil series.

Class means for the four significant variables are given in Tables 18 through 21. The relationships between SI and drainage class and between SI and moisture regime appear to be non-linear: productivity is generally higher for classes in the middle than for those at either end. Sites that are very dry or very wet are not as productive as moderately well or imperfectly drained (mesic to subhygric) sites. The SNK means test showed rapidly drained sites to differ significantly from imperfectly drained sites. Sites with subhygric moisture regime differed significantly from xeric, subxeric and hygric sites (all that had sufficient data to test).

Table 17. Significance of F statistic for discrete variables.

Variable	Dependent Variable SI	MAI
Drainage Class	<0.001**	.317
Humus Form	.674	.756
Landform	.706	.913
Macro Slope Position	.822	.389
Meso Slope Position	.324	.722
Moisture Regime	.006**	.468
Nutrient Regime	.284	.304
Soil Subgroup	.002**	.576
Soil Series	.024*	.324
ELC Subregion	.931	.223
Texture of A	.173	.795
Texture of B	.993	.528
Texture of C	.103	.136

* significant at 0.05

** significant at 0.01

Table 18. Mean site index by drainage class.

Drainage Class	SI	n
1 (very rapid/rapid)	14.65 a	22
2 (well drained)	17.33 ab	3
3 (moderately well)	11.30 -	1
4 (imperfect)	19.50 b	5
5 (poor)	16.20 ab	1
6 (very poor)	9.80 -	1
All	15.54	37

Note: ANOVA and the SNK tests are based only on classes with 2 or more observations (Mean SI then 15.83). In the table, means with the same letter dencte no significant difference between the means based on the SNK test (with an alpha value of 0.05).

Table 19. Mean site index by moisture regime.

Moisture Regime	SI	n
2 (Xeric)	14.95 a	15
3 (Subxeric)	15.11 a	9
4 (Submesic)	11.30 -	1
5 (Mesic)	15.20 -	1
6 (Subhygric)	19.25 b	6
7 (Hygric)	15.75 a	4
8 (Subhydric)	9.80 -	1
All	15.54	37

Note: ANOVA and the SNK tests are based only on classes with 2 or more observations (Mean SI then 15.85). In the table means with the same letter denote no significant difference between the means based on the SNK test (with an alpha value of 0.05).

Table 20. Mean site index by soil subgroup.

Soil Group	SI	n
Eluviated Dystric Brunisol	15.08*	17
Eluviated Eutric Brunisol	13.78	4
Gleyed Eluviated Dystric Brunisol	19.80*	3
Gleyed Eluviated Eutric Brunisol	19.05*	2
Orthic Eutric Brunisol	12.80*	3
Orthic Gleysol	17.37	3
Orthic Gray Luvisol	18.50	2
Rego Gleysol	14.45	2
Terric Mesisol	9.80 -	1
ALL	15.54	37

Note: ANOVA and the SNK tests were based only on classes with 2 or more observations (Mean SI then 15.75). Based on the SNK test with an alpha value of 0.05, the following soil groups are significantly different:

- Gleyed Eluviated Dystric Brunisol is different than Orthic Eutric Brunisol, Eluviated Eutric Brunisol and Eluviated Dystric Brunisol;
- Gleyed Eluviated Eutric Brunisol is different than Orthic Eutric Brunisol.

The gleyed soils (Gleyed Eluviated Dystric Brunisols and Gleyed Eluviated Eutric Brunisols) have greater moisture availability due to temporary perched water tables. The higher site index is therefore likely a result of greater moisture availability for part of the growing season.

Table 21. Mean site index by soil series.

Soil Series	SI	n
Kettlehills	16.50 ab	3
Lonesand	19.80 a	3
Malonton	13.70 -	1
Pine Ridge	14.38 ab	6
Sandilands	14.77 b	14
Sundown	16.82 ab	4
Wintergreen	19.05 ab	2
Woodridge	14.73 ab	3
ALL	15.70	36

Note: ANOVA and the SNK tests were based only on classes with two or more observations (Mean SI then 15.72). Means with the same letter denote no significant difference between the means based on the SNK test (with an alpha value of 0.05).

Lonesand soils (Gleyed Eluviated Dystric Brunisols) have significantly greater site index than Sandilands soils (Eluviated Dystric Brunisols). The major difference between these soils is the wetter moisture regime in Lonesand soils -- which agrees with the information presented in Table 20. Surprisingly the Kettlehills soils (very dry Dystric Brunisols on sand dunes) are not significantly different from Lonesand soils -- but sample sizes were small.

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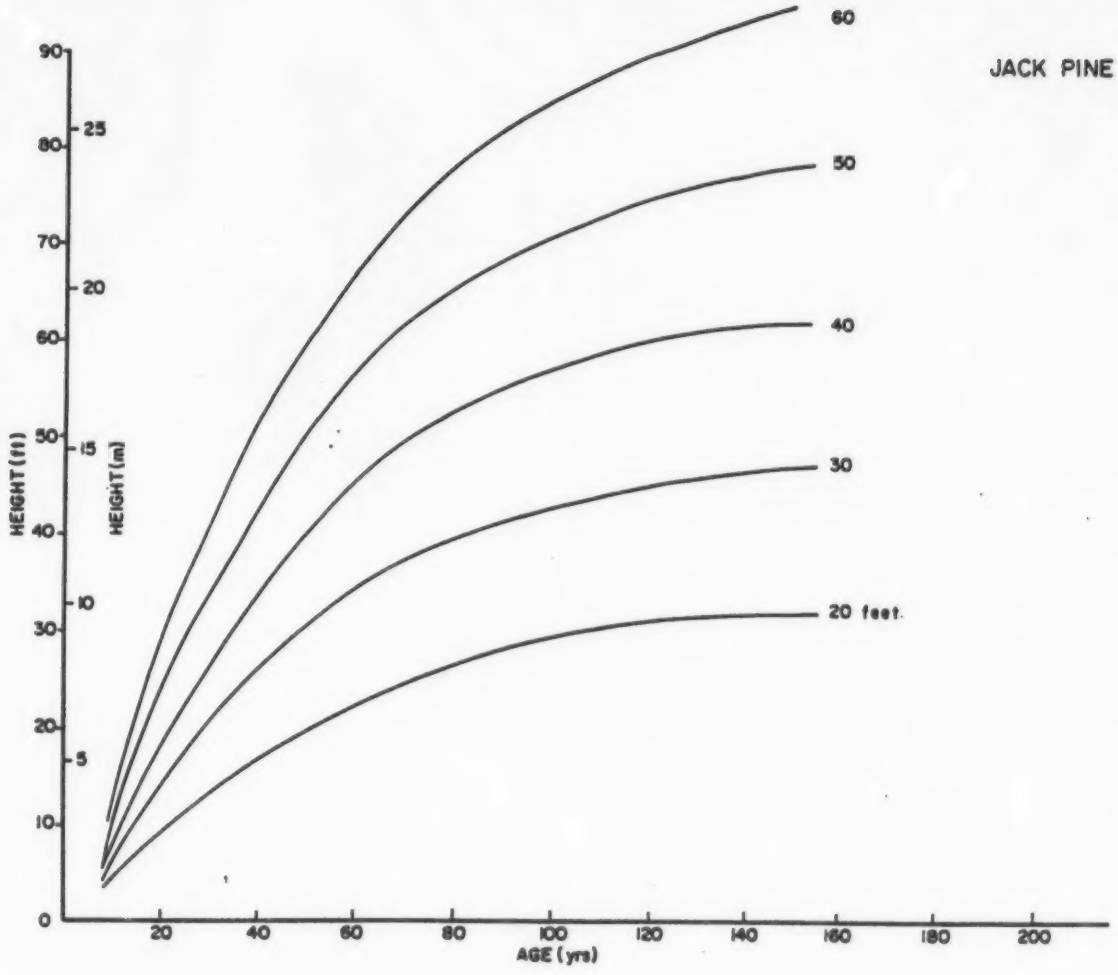
APPENDIX I

SITE INDEX CURVES

Data Source: Manitoba Forestry Branch (not dated)
- adapted from imperial to metric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50
40
30
20 feet.
HEIGHT (ft)
HEIGHT (m)
AGE (yrs)
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10
20
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40
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70
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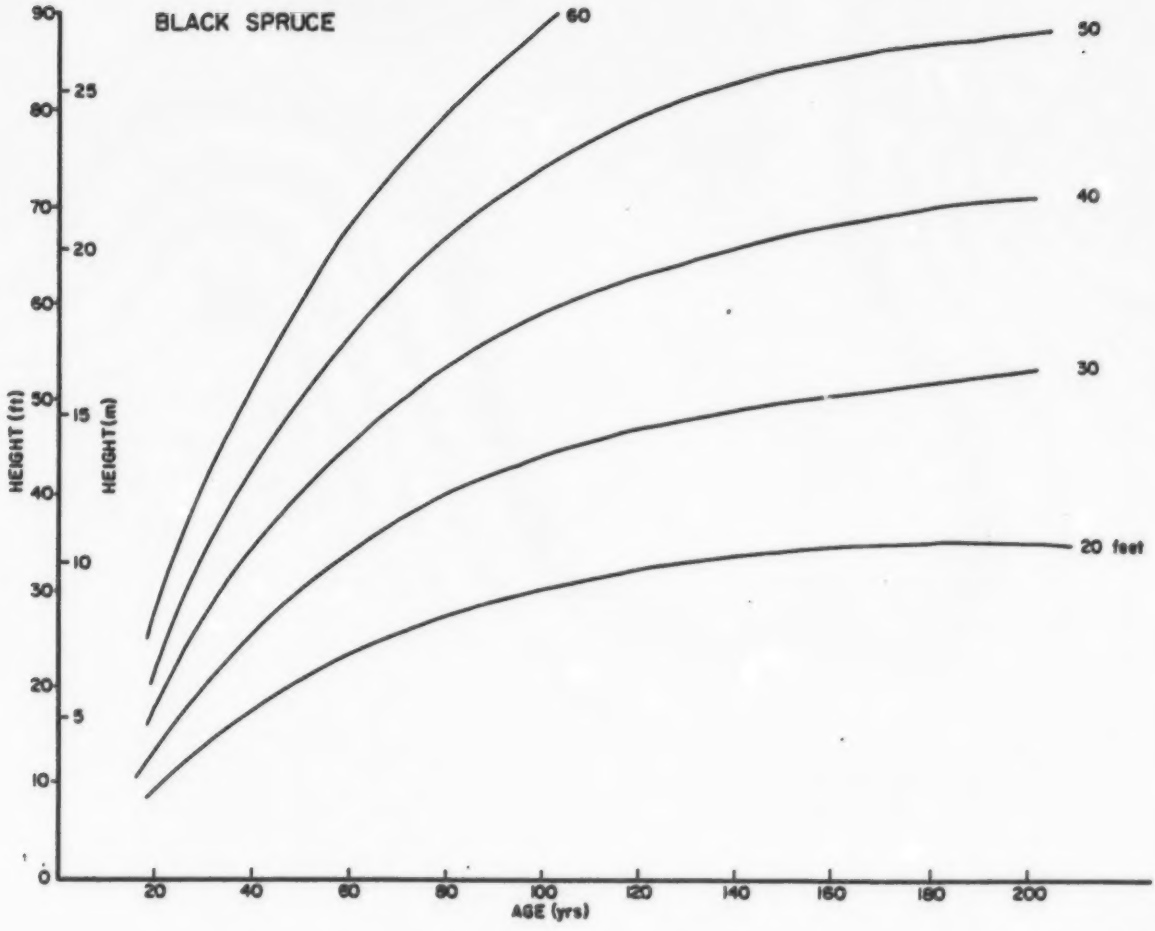
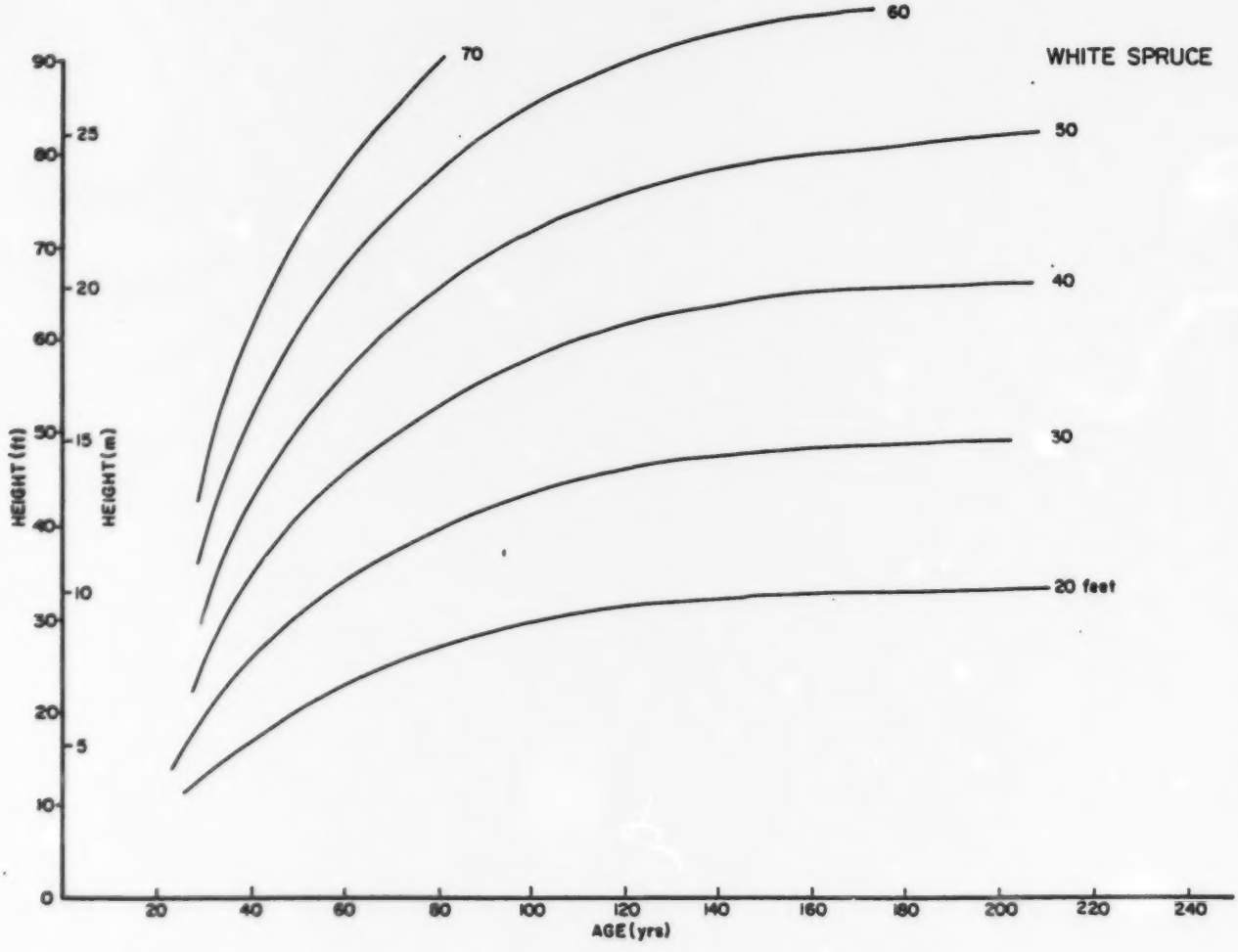
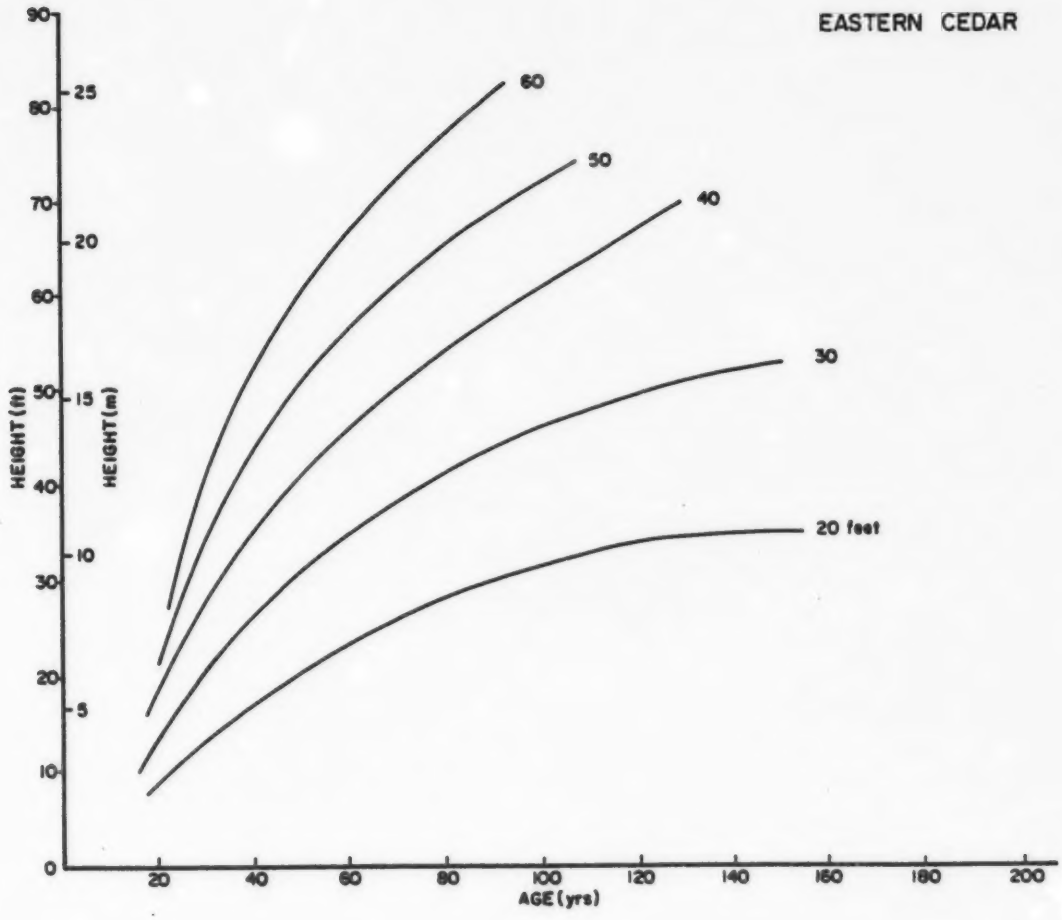
160
180
200


BLACK SPRUCE
HEIGHT (ft)
HEIGHT (m)
AGE (yrs)
60
50
40
30
20 feet
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25
20
40
60
80
100
120
140
160
180
200


WHITE SPRUCE
70
60
50
40
30
20 feet
HEIGHT (ft)
HEIGHT (m)
AGE (yrs)
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25
20
40
60
80
100
120
140
160
180
200
220
240


EASTERN CEDAR
HEIGHT (ft)
HEIGHT (m)
AGE (yrs)
60
50
40
30
20 feet
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25
20
40
60
80
100
120
140
160
180
200

APPENDIX II

VEGETATION DATA

LEVEL	ZONE	ASSC	TYPE
ECOSYN UNIT			

PINU BAN/ARCT UVA/CLADONIA SPP.

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 23, 1960

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 1 PAGE 1

PLOT NUMBER	AVERAGE VALUE		000 0029		000 0036		000 0039	
NUMBER OF SPECIES PER PLOT	22.0		21		28		17	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV
A1 LAYER								
1 PINU BAN K	100.0	19.0	20		17		20	
B1 LAYER								
2 ABIE BAL S	33.3	0.3					01	
3 PRUN PEN N	33.3	0.2	.5					
B2 LAYER								
4 ARCT UVA	66.7	10.7	07				35	
5 VACC ANG U	66.7	4.2	12				.5	
6 SAUL PRO C	66.7	0.5	.5				01	
7 ROSA ACI C	66.7	0.3	.5		.5			
8 SPIR ALB U	33.3	1.0			03			
9 PRUN VIR G	33.3	0.7			02			
10 JUNI COM N	33.3	0.3					01	
11 AMEL ALN I	33.3	0.2	.5					
12 HUDS TOM S	33.3	0.2	.5					
13 HUDS TOM S	33.3	0.2			.5			
PRUN PEN N	33.3	0.2	.5					
14 RUBU IDA S	33.3	0.2			.5			
15 SYMP ALB U	33.3	0.2			.5			
C LAYER								
16 MAIA CAN A	66.7	1.0	02				01	
17 APOC AND R	66.7	0.3	.5		.5			
18 SOLI NIS P	66.7	0.3			.5		.5	
19 SELA RUP S	33.3	0.7			02			
20 ANEM QUI N	33.3	0.2	.5					
21 ARTE CAM P	33.3	0.2					.5	
22 ASTE LAE Y	33.3	0.2	.5					
23 CAMP ROT U	33.3	0.2			.5			
24 CARE RIC H	33.3	0.2	.5					
25 CARE SIC C	33.3	0.2					.5	
26 CORN CAN A	33.3	0.2					.5	
27 EPIL ANG U	33.3	0.2			.5			
28 MELA LIN S	33.3	0.2					.5	
29 PYRO SEC U	33.3	0.2			.5			
30 SENE PAU P	33.3	0.2			.5			
31 SOLI DEC U	33.3	0.2			.5			
G LAYER								
32 ORYZ PUN S	100.0	0.7	.5		01		.5	
33 AGRO SCA S	66.7	0.3			.5		.5	
34 ANDR GER A	66.7	0.3	.5		.5			
35 ORYZ ASP S	33.3	0.2	.5					
36 SCHI PUR P	33.3	0.2	.5					
B LAYER								
37 DICR SP	100.0	0.2	15		.5		03	
38 POLY PIL I	33.3	0.7			20			
39 CERA PUR P	33.3	0.3			01			
L LAYER								
40 CLAD MIT I	100.0	3.6	03		05		.5	

LEVEL	ZONE	ASSC	TYPE
ECOSYN UNIT			

PINU BAN/ARCT UVA/CLADONIA SPP.

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 23, 1960

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 1 PAGE 2

PLOT NUMBER	AVERAGE VALUE		000 0029		000 0036		000 0039	
NUMBER OF SPECIES PER PLOT	22.0		21		28		17	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV
41 CLAD RAN S	100.0	2.7	06		01		02	
42 CLAD MUL T	33.3	1.0			03			
43 CLAD CBC C	33.3	0.2			.5			
44 CLAD GRA C	33.3	0.2			.5			
45 CLAD UNC I	33.3	0.2			.5			
46 CLAD VER Y	33.3	0.2			.5			

LEVEL	ZONE	ASSC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 22, 1988

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 2 PAGE 1

PLOT NUMBER	AVERAGE VALUE		000 0001		000 0012		000 0018		000 0025		000 0028		000 0035	
NUMBER OF SPECIES PER PLOT	31.0		34		38		38		27		38		27	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV	%C	SV	%C	SV	%C	SV
A1 LAYER														
1 PINU BAN K	100.0	16.7	16		20		17		20		20		20	
B1 LAYER														
2 PRUN VIR G	33.3	0.3									01		.5	
3 ALNU CRI S	16.7	1.0									06			
4 SALI SEB S	16.7	0.6									06			
5 QUER MAC R	16.7	0.2			01									
6 AMEL ALN I	16.7	0.1									.5			
7 BETU PAP Y	16.7	0.1	.5											
8 POPU TRE W	16.7	0.1			.5									
B2 LAYER														
9 ROSA ACI C	100.0	3.5	01		05		04		04		05		02	
AMEL ALN I	100.0	1.6	01		01		02		06		01		01	
10 ARCT UVA	83.3	4.7	01		06		10		06				03	
11 VACC AMB U	83.3	3.7	04		01		06		02		03			
12 SYMP ALB U	83.3	1.3			04		.5		01		02		.5	
PRUN VIR S	83.3	0.5	.5		.5				01		.5		.5	
13 LONI DIO I	66.7	0.3			.5		.5				.5		.5	
14 RUBU IDA E	50.0	0.5	.5								02		.5	
15 GAUL PRO C	50.0	0.3					01				.5		.5	
SALI SEB S	33.3	0.6									03		.5	
16 CORY COR H	33.3	0.2			.5								.5	
17 JUNI COM H	16.7	0.3			02									
18 SYMP ALB U	16.7	0.3	02											
19 CEAN AVA Y	16.7	0.2					01							
20 CORN ALT E	16.7	0.2							01					
ALNU CRI S	16.7	0.1									.5			
BETU PAP Y	16.7	0.1	.5											
21 LONI DIO I	16.7	0.1	.5											
22 RIBE TRI S	16.7	0.1	.5											
23 SHEP CAN A	16.7	0.1			.5									
24 SPIR ALB U	16.7	0.1					.5							
25 VIBU RAF I	16.7	0.1			.5									
C LAYER														
26 APOC AND R	100.0	0.5	.5		.5		.5		.5		.5		.5	
27 ASTE LAE Y	100.0	0.5	.5		.5		.5		.5		.5		.5	
28 MAIA CAN A	83.3	5.5	.5		04		01				04		35	
29 LATH OCH R	83.3	1.2			02		01		01		01		02	
30 ARGM GUI N	83.3	0.5	.5		.5		01				.5		.5	
31 CAMP ROT U	83.3	0.4	.5		.5		.5		.5		.5			
32 LITH CAN E	66.7	0.3			.5		.5				.5		.5	
33 FRAG VIR S	50.0	0.7	02		01						01			
34 SALI BOR E	50.0	0.3			.5		01		.5					
35 POTE TRI D	50.0	0.2	.5				.5		.5					
36 PYRO SEC U	50.0	0.2	.5				.5				.5			
37 ARAL NUD I	33.3	0.8	04								.5			
38 THAL VEN U	33.3	0.4			02						.5			
39 EPIL ANG U	33.3	0.3	01								.5			

LEVEL	ZONE	ASSC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 22, 1988

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 2 PAGE 2

PLOT NUMBER	AVERAGE VALUE		000 0001		000 0012		000 0018		000 0025		000 0028		000 0035	
NUMBER OF SPECIES PER PLOT	31.0		34		38		38		27		38		27	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV	%C	SV	%C	SV	%C	SV
40 LIBB BOR E	33.3	0.3	01										01	
41 ASTE RAC E	33.3	0.2			.5				.5					
42 CARE RIC H	33.3	0.2							.5		.5			
43 COMA PAL L	33.3	0.2			.5				.5					
44 EQUI LAE V	33.3	0.2	.5										.5	
45 VICI AME R	33.3	0.2			.5		.5							
46 CORN CAN A	16.7	1.2	07											
47 PTER AQU I	16.7	0.5									03			
48 LYCO COM P	16.7	0.2	01											
49 ARGM PAT E	16.7	0.1					.5							
50 ASTE CIL I	16.7	0.1					.5							
51 CHUM UMB E	16.7	0.1	.5											
52 SALI TRF L	16.7	0.1	.5											
53 MERC RIC H	16.7	0.1									.5			
54 MIER UMB E	16.7	0.1					.5							
55 MELA LIN E	16.7	0.1			.5									
56 SOLI SEC U	16.7	0.1							.5					
57 SOLI MIS P	16.7	0.1											.5	
58 SOLI SP	16.7	0.1			.5									
59 TRIE BOR E	16.7	0.1	.5											
60 VIOL ADU H	16.7	0.1											.5	
G LAYER														
61 ORYZ ASP E	100.0	4.6	16		01		03		.5		05		03	
62 ORYZ PUN S	83.3	0.6			.5		.5		.5		.5		.5	
63 ECHI PUR P	66.7	1.0	04		.5						01		.5	
64 AMDR GER A	16.7	0.3							02					
D LAYER														
65 PLEU SCH R	66.7	7.8	20		05						20		01	
66 DICR SP	66.7	1.0	.5		04						.5		01	
67 BRAC SP	33.3	0.3			.5						01			
68 POLY JUN I	16.7	0.2							01					
L LAYER														
69 CLAD RAN G	33.3	0.2	.5						.5					
70 CLAD SRA C	16.7	0.1							.5					
71 CLAD MIT I	16.7	0.1							.5					
72 CLAD MUL T	16.7	0.1							.5					
73 CLAD SP	16.7	0.1			.5									
74 PELT MAL A	16.7	0.1							.5					

LEVEL	ZONE	ASSOC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA/PLEU SCH

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 22, 1988
PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 3 PAGE 1

PLOT NUMBER	AVERAGE VALUE	000 0002	000 0013	000 0019	000 0018	000 0017	000 0016	000 0021	000 0023	000 0027	000 0031	000 0032	000 0034	000 0037	000 0004	000 0020
NUMBER OF SPECIES PER PLOT	28.0	30	27	32	30	34	24	29	31	26	28	33	29	30	26	30
SPECIES	%P MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
A1 LAYER																
1 PINU BAN K	93.8 29.0	29	25	29	29	29	15	29	25	15	29	29	29	29	29	17
2 PISA BAN K	6.3 1.8								25							
B1 LAYER																
3 AMEL ALN I	18.8 0.1			.5	.5				.5							
4 PRUN VIR S	18.8 0.1				.5					.5				.5		
5 CORY COR N	6.3 0.1												01			
6 PRUN PEN N	6.3 0.1												02			
7 ALNU CRI S	6.3 0.1											.5				
PINU BAN K	6.3 0.0															
B2 LAYER	6.3 0.0	.5														
8 VACC MYR V	93.8 3.1	02	.5	04	01	02	10		06	04	02	05	02	02	01	02
9 ROSA ACI C	87.5 2.8	01	02	06	01	04	04		04	02	.5	03	04		01	01
10 ARCT UVA	81.3 5.4	10			03	12	04	01	03	12	20		01	25	15	20
ARCT UVA	81.3 1.4	02	.5	.5	02	01	06	.5	02	02			03	01	.5	01
AMEL ALN I	75.0 0.8		.5	.5	.5	01	01	.5	06	.5			01	01	.5	.5
11 SYMP ALB U	68.8 0.4	.5	.5	.5		.5	.5			01	.5		.5	01	.5	.5
PRUN VIR S	56.3 0.6	.5				01	.5		.5	02	05	.5		01	01	
12 GAUL PRO C	37.5 0.2		.5	.5			.5			.5				01		.5
13 LONI DIO I	28.0 0.2	01			.5										.5	01
14 JUNI COM N	28.0 0.1		.5	.5					.5			.5				
15 RUBU IDA E	28.0 0.1			.5				.5			.5		.5			
16 SPIR ALB U	18.8 0.1	.5				.5								02		02
17 SPIR ALB A	12.5 0.2											.5				
18 CORN ALT S	12.5 0.1			01								.5				
19 CORN STO L	12.5 0.1			.5								.5				
20 RIBE TRI S	12.5 0.1									02						
21 SALI BEB B	6.3 0.1												01			
22 SIER LON I	6.3 0.1													.5		
PRUN PEN N	6.3 0.0											.5				
23 APIR ALB U	6.3 0.0											.5				
24 SHYU PAP Y	6.3 0.0											.5				
25 RHUS RAD I	6.3 0.0															
26 RIBE GRY A	6.3 0.0															
27 RIBE SP	6.3 0.0			.5												
28 SAMB RED R	6.3 0.0			.5												
29 SHEP CAN A	6.3 0.0		.5													
C LAYER																
30 MAIA CAN A	87.5 1.7	04	.5	04	.5	.5		.5	.5	04	04	01	01	04	01	01
31 ARNM NUI N	87.5 0.7	.5	.5	01	01	01	.5		01	.5	.5	.5	.5	01	02	01
32 ASTE LAE V	75.0 0.4	.5			.5	.5	.5	.5	.5	.5	.5			.5	.5	.5
33 GALI BOR E	75.0 0.4	.5	.5	.5	.5	.5	.5		.5			.5	.5	.5	.5	.5
34 LITH CAN E	62.5 0.3				.5	.5	.5	.5	.5	.5			.5	.5	.5	.5
35 LATH OCH R	56.3 1.0	.5	.5		04	02	04	01	03				.5	02		
36 FRAG VIR S	50.0 0.6	.5		03		01	01	.5	01				01		.5	.5
37 POTE TRI D	50.0 0.3	.5				.5	.5		.5	.5	.5	.5	.5	.5	.5	.5
38 SOLI NIS P	50.0 0.3		.5					.5	.5	.5	.5	.5	.5	.5	.5	.5
39 APOC AND R	50.0 0.3	.5	.5		.5		01	.5		.5		.5	.5	.5	.5	.5
40 CAMP ROT U	50.0 0.3	.5				.5		.5		.5		.5	.5	.5	.5	.5

LEVEL	ZONE	ASSOC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA/PLEU SCH

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 22, 1988
PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 3 PAGE 2

PLOT NUMBER	AVERAGE VALUE	000 0002	000 0013	000 0019	000 0018	000 0017	000 0016	000 0021	000 0023	000 0027	000 0031	000 0032	000 0034	000 0037	000 0004	000 0020
NUMBER OF SPECIES PER PLOT	28.0	30	27	32	30	34	24	29	31	26	28	33	29	30	26	30
SPECIES	%P MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
41 VIOL ADU N	50.0 0.3					.5		.5	.5	.5		.5	.5	.5	.5	
42 ASTE CIL I	37.5 0.2		.5	.5		.5								.5		
43 EQUI LAE V	37.5 0.2	.5	.5		.5			.5	.5		.5					.5
44 SOLI DEC U	37.5 0.2	.5				.5		.5	.5							
45 ANTE RAC E	31.3 0.2					.5		.5			.5		.5	.5		
46 CHIM UMB E	31.3 0.2										01	.5	01	01		
47 LINN BOR E	28.0 0.8	02		.5		.5						05				
48 EPIL ANG U	28.0 0.2			01								.5	.5		.5	
49 ANEM MUL Y	28.0 0.1				.5				.5	.5	.5			.5		
50 ANTE LUD S	28.0 0.1					.5	.5	.5			.5					.5
51 CARE RIC H	28.0 0.1											02				
52 CORN CAN A	18.8 0.3		.5	02									02			
53 THAL VEN U	18.8 0.2			.5			02									
54 ARAL NUD I	12.5 0.3		.5						05							
55 CYPR ACA U	12.5 0.1					.5		.5								
56 MELA LIN E	12.5 0.1												.5			.5
57 TRIE BOR E	12.5 0.1	.5		.5									.5			
58 VICI AME R	12.5 0.1		.5									03				
59 PTER AQU I	6.3 0.2			03												
60 RUBU PUB E	6.3 0.1				01											
61 ABCL SP	6.3 0.1	01							1							
62 CARE SP	6.3 0.0														.5	
63 ARBS SLA U	6.3 0.0													.5		
64 ANEM PAT E	6.3 0.0															
65 CALA PAL U	6.3 0.0							.5								
66 CARE SIC C	6.3 0.0															
67 EPIG REP E	6.3 0.0		.5													
68 EQUI SYL V	6.3 0.0			.5												
69 GALI TRF L	6.3 0.0			.5												
70 GEUM REP E	6.3 0.0					.5										
71 MEUC RIC H	6.3 0.0							.5								.5
72 HIER SP	6.3 0.0														.5	
73 HIER SP.	6.3 0.0												.5			
74 MERT ARV E	6.3 0.0													.5		
75 POTA SAG I	6.3 0.0															
76 RUPU PUB E	6.3 0.0		.5													
77 SMIL STE L	6.3 0.0															
78 SOLI SP	6.3 0.0					.5										
C LAYER																
79 ORYZ ASP E	93.8 1.6	01	01		05	.5	03	.5	02	.5	.5	.5	.5	05	.5	01
80 SCHI PUR P	93.8 0.5	.5	.5	.5	.5	.5	01	.5	.5	.5	.5	.5	01	.5	.5	.5
81 ORYZ PUN S	81.3 0.4	.5	.5		.5	.5			.5	.5	.5			.5		
82 ANDR GER A	28.0 0.1										.5					
83 CALA CAN A	6.3 0.0				.5											
B LAYER																
84 PLEU SCH R	93.8 58.3	05	05	70	50	75	50	05	70	30	50	50	50	.5	05	70
85 BICR SP	93.8 2.4	04	02	01	.5	02		01	01	02	04	01	01	03	02	05
86 BRAC SP	18.8 0.1			.5	.5		.5									

LEVEL	ZONE	ASSOC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA/PLEU SCH

RESOURCE INVENTORY
EDMONTON, ALBERTA
10:17:22 MAR 23, 1989

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 3 PAGE 3

PLOT NUMBER	AVERAGE VALUE	0002	0013	0015	0016	0017	0018	0021	0022	0027	0031	0032	0034	0037	0004	0026
NUMBER OF SPECIES PER PLOT	29.0	30	27	32	30	34	24	29	31	30	29	33	30	30	29	30
SPECIES	%P MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
87 PTIL CRI C	6.3 0.1															
88 HYLO SPL S	6.3 0.0								.5							
L LAYER																
89 CLAD RAN G	75.0 4.5	02			.5	02		03	.5	.5	.5	.5		05	03	01
90 CLAD MIT I	43.8 0.4	.5						01			.5	.5		.5	01	
91 CLAD MUL T	12.5 0.1											.5				
92 CLAD UNC I	12.5 0.1					01										
93 CLAD STE L	6.3 0.0					.5										

LEVEL	ZONE	ASSOC	TYPE
ECOSYM UNIT			

PINU BAN/ARCT UVA/PLEU SCH

RESOURCE INVENTORY
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PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V) TABLE 3 PAGE 4

PLOT NUMBER	0030
NUMBER OF SPECIES PER PLOT	28
SPECIES	%C SV
A1 LAYER	
1 PIBB BAN K	35
2 PIBA BAN K	
B1 LAYER	
3 AMEL ALN I	
4 PRUN VIR S	
5 COMT COR N	
6 PRUN PEN N	
7 ALNU CRI S	
PIBB BAN K	
B2 LAYER	
8 VACC ANG U	01
9 ROSA ACI C	.5
10 ARCT UVA	04
AMEL ALN I	
11 SYMP ALB U	
PRUN VIR S	
12 GAUL PRO C	
13 LONI DIO I	
14 JUNI COM M	
15 RUBU IDA S	
16 SPIR ALB U	
17 SPIR ALB A	01
18 CORN ALT S	
19 CORN STO L	
20 RIBE TRI S	
21 SALI BEB S	.5
22 DIER LON I	
PRUN PEN N	
23 APIR ALB U	
24 BETU PAP Y	
25 RHUS RAD I	
26 RIBE GRY A	
27 RIBE SP	
28 SAXE BEB S	
29 SHEP CAN A	
C LAYER	
30 MAIA CAN A	
31 ANEM QUI S	
32 ASTE LAE V	.5
33 GALI BOR E	.5
34 LITH CAN E	
35 LATH OCH A	
36 FRAG VIR S	
37 POTE TRI S	
38 SOLI NIG P	.5
39 APOC AND A	
40 CAMP ROT U	

LEVEL | 2ORE | ASSC | TYPE

ECOSYM UNIT

PINU BAR/ARCT UVA/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	000 0030
NUMBER OF SPECIES PER PLOT	28
SPECIES	%C SV
41 VIBL ADU H	.5
42 ASTE CIL I	.5
43 EQUI LAE V	
44 SOLI RDC U	.5
45 ASTE RAC S	.5
46 CHIM UMB S	.5
47 LINN BOR S	
48 EPIL ADE U	
49 ARCO MUL T	.5
50 ASTE LUD S	
51 CARE BIC M	.5
52 COMM CAN A	
53 THAL VEN U	
54 ARAL NUD I	
55 CYPR ACA U	
56 MELA LIN S	
57 TRIE BOR S	
58 VICI AME R	
59 PTER AQU I	
60 RUBU PUB S	
61 ABIE SP	
62 CARE SP	
63 ARCO SLA U	.5
64 ARCO PAT S	
65 CALA PAL U	
66 CARE BIC C	
67 EPIC ASP S	
68 EQUI SYL V	
69 GALI TRI L	
70 GOOD REP S	
71 HEDE BIC M	
72 HIER SP	
73 HIER SP.	
74 MERT ARV S	
75 PETA DAS I	
76 RUPU PUB S	
77 SMIL STE L	.5
78 SOLI SP	
S LAYER	
79 ORYZ ASP S	.5
80 SCHI PUR P	.5
81 ORYZ PUR S	.5
82 ARCO GEO A	.5
83 CALA CAN A	
H LAYER	
84 PLEU SCH R	
85 PICE SP	10
86 SHAC SP	

RESOURCE INVENTORY
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TABLE 3 PAGE 9

LEVEL | 2ORE | ASSC | TYPE

ECOSYM UNIT

PINU BAR/ARCT UVA/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	000 0030
NUMBER OF SPECIES PER PLOT	28
SPECIES	%C SV
87 PTIL CRI C	01
88 MYLO SPI S	
L LAYER	
89 CLAD RAN S	08
90 CLAD MIT I	03
91 CLAD MUL T	.5
92 CLAD UNC I	01
93 CLAD STE L	

PLOT NUMBER	AVERAGE VALUE		000 0002	000 0005	000 0006	000 0007	000 0008	000 0009	000 0020	000 0033	000 0040	000 0041
NUMBER OF SPECIES PER PLOT	34.6		29	28	36	46	36	44	34	32	25	36
SPECIES	%P	MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
A1 LAYER												
1 POPU TRE M	60.0	12.0		10	20	25		35		05	25	
2 PICE GLA U	20.0	3.5					25		10			
3 PINU BAN K	20.0	3.5								25		10
4 PINU RES I	10.0	2.0	20									
5 LARI LAR I	10.0	0.7		07								
A2 LAYER												
POPU TRE M	40.0	1.5					04	05	01			05
6 BETU PAP Y	20.0	0.5						05	01			
PICE GLA U	20.0	0.3				02			01			
7 ABIE BAL S	10.0	0.5					05					
8 PICE MAR I	10.0	0.5				05						
9 THUJ OCC I	10.0	0.3		03								
10 POPU BAL S	10.0	0.0		.5								
S1 LAYER												
POPU TRE M	80.0	0.5			03			03		.5	01	01
11 AMEL ALN I	50.0	0.3				01	.5	.5	.5			.5
PICE GLA U	30.0	0.5			02	02		01				
12 ALNU RUG S	20.0	0.7		04	03							
13 SALI SP	20.0	0.5			03						03	
14 CORY COR M	20.0	0.5					03	02				
15 PRUN VIR S	20.0	0.3						02	.5			
BETU PAP Y	20.0	0.1					.5		.5			
16 SALI BEB S	20.0	0.1							.5			.5
17 FRAX PEN N	10.0	1.5						15				
ABIE BAL S	10.0	1.2					12					
18 VIBU TRI L	10.0	0.5		05								
LARI LAR I	10.0	0.4			04							
19 SALI EXP	10.0	0.3		03								
PICE MAR I	10.0	0.1				01						
20 ALNU CRI S	10.0	0.0										.5
21 CORN STO L	10.0	0.0						.5				
PINU BAN K	10.0	0.0										.5
22 PRUN PEN N	10.0	0.0					.5					
S2 LAYER												
23 ROSA ACI C	100.0	3.2	02	03	10	04	04	03	04	02	.5	.5
CORN STO L	80.0	1.2			07	01	01	01			01	01
AMEL ALN I	80.0	1.0	02			05		.5	02	.5		.5
POPU TRE M	80.0	0.5			02	.5			01	.5	01	.5
24 VACC AMB U	80.0	1.5	02			.5			01	03		12
25 SYMP ALB U	80.0	1.1	05			03	02		.5	01		
26 LONI DIO I	80.0	0.3		.5		.5	.5	.5		.5		
27 RIBE SP	80.0	0.2		01	.5	.5		.5		.5		
CORY COR M	40.0	2.5					05	02	20		01	
28 SPIR ALB A	30.0	0.2	.5	.5	02							
29 LONI VIL L	20.0	1.5		12	04							
30 BETU PUM I	20.0	1.1		05	03							
31 LEDU GRO E	20.0	1.1				04						07

PLOT NUMBER	AVERAGE VALUE		000 0002	000 0005	000 0006	000 0007	000 0008	000 0009	000 0020	000 0033	000 0040	000 0041
NUMBER OF SPECIES PER PLOT	34.6		29	28	36	46	36	44	34	32	25	36
SPECIES	%P	MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
32 RUBU IDA E	20.0	0.2		01								01
PICE GLA U	20.0	0.1		.5		01						
PRUN VIR S	20.0	0.1				.5			01			
33 RIBE TRI S	20.0	0.1					.5	.5				
SALI BEB S	20.0	0.1				.5						.5
34 SHEP CAN A	20.0	0.1				01						.5
ABIE BAL S	10.0	0.7					07					
35 ARCT UVA	10.0	0.7	07									
FRAX PEN N	10.0	0.4						04				
ALNU CRI S	10.0	0.3										03
36 RHUS RAD I	10.0	0.3						03				
VIBU TRI L	10.0	0.2				03						
BETU PAP Y	10.0	0.0								.5		
37 RIBE LOM I	10.0	0.0					.5					
38 GAUL PRO C	10.0	0.0				.5						
39 LONI INV O	10.0	0.0				.5						
PICE MAR I	10.0	0.0				.5						
40 POTE FRU T	10.0	0.0				.5						
41 RIBE ODY A	10.0	0.0						.5				
SALI SP	10.0	0.0									.5	
42 SPIR ALB U	10.0	0.0								.5		
43 THUJ OCC I	10.0	0.0										.5
44 VIBU RAF E	10.0	0.0							.5			
45 VIBU RAF I	10.0	0.0									.5	
C LAYER												
46 FRAG VIR S	100.0	1.5	.5	.5	10	02	02	01	.5	.5	.5	.5
47 MAIA CAN A	80.0	1.4		.5	02	02	01	.5	01	04	02	.5
48 SALI BEB E	80.0	0.4	.5	.5	.5	.5	.5	.5	.5	.5		.5
49 ANEM QUI N	60.0	0.4			.5	.5	.5	01	.5	.5	.5	.5
50 LATH OCH R	60.0	0.4	.5		.5	.5	.5	.5	01	.5		.5
51 ASTE CIL I	70.0	0.5			.5	01	01	01		.5	01	.5
52 CORN CAN A	60.0	3.5				05	05	02	.5	20		33
53 ARAL NUD I	60.0	1.3				03		03	04	02	.5	01
54 PETA PAL M	60.0	0.4		.5		01	01	.5				01
55 SMIL STE L	60.0	0.3		.5	.5	.5	.5	.5			.5	
56 RUBU PUB E	40.0	0.5		05			.5			02		.5
57 EPIL ANG U	40.0	0.2		.5				.5		.5		.5
58 VICI AME R	40.0	0.2		.5	.5				.5			.5
59 LINN BOR E	30.0	0.4				03				01		.5
60 RUPU PUB E	30.0	0.3			.5			02	.5			
61 BOTR VIR S	30.0	0.1				.5	.5	.5				
62 DISP TRA C	30.0	0.1				.5	.5	.5				
63 EQUI ARV E	30.0	0.1			.5	.5				.5		
64 GALI TRF L	30.0	0.1						.5		.5	.5	
65 VIOL ADU W	30.0	0.1	.5					.5	.5			
66 PYRO ASA I	20.0	3.5							05			30
67 ACTA RUB R	20.0	0.1				.5	.5					
68 APOC AND R	20.0	0.1							.5			.5

LEVEL | ZONE | ASSC | TYPE

ECOSYM UNIT | | | |

PICE GLA-PSPU TRE/CORY COR/ARAL HUD

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0002	000 0004	000 0005	000 0007	000 0008	000 0009	000 0020	000 0032	000 0040	000 0041
NUMBER OF SPECIES PER PLOT	36.8		39	39	38	46	39	44	34	32	38	38
SPECIES	%P	MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
69 ASTE CON S	20.0	0.1			.5		.5	.5				
70 CARE SP	20.0	0.1		01			.5					
71 LYSI TER R	20.0	0.1			.5	.5					.5	
72 MELA LIN R	20.0	0.1				.5					.5	
73 PYRO ELL I	20.0	0.1			.5						.5	
74 TARA OFF I	20.0	0.1			.5				.5			
75 THAL DAS Y	20.0	0.1					.5					
76 THAL VEN U	20.0	0.1	.5			.5				.5		.5
77 TRIS SPI E	20.0	0.1					.5	.5				
78 VIOL REN I	20.0	0.1									01	
79 CIRS SP	10.0	0.1										
80 ARTE RAC E	10.0	0.0	.5								.5	
81 ASTE SP	10.0	0.0										
82 CAMP ROT W	10.0	0.0	.5									.5
83 CLIN SBA E	10.0	0.0										
84 COMA PAL L	10.0	0.0	.5									
85 EQUI LAE V	10.0	0.0			.5					.5		
86 EQUI SYL V	10.0	0.0										
87 GALI TRI P	10.0	0.0		.5				.5				
88 HELE DEP L	10.0	0.0										
89 IRIS VER S	10.0	0.0			.5							
90 MERT ARV E	10.0	0.0			.5							
91 MITE NUD A	10.0	0.0					.5					
92 MITE NUD I	10.0	0.0		.5								
93 PETA SAG I	10.0	0.0			.5							
94 PRUN VUL S	10.0	0.0			.5			.5				
95 PYRO ASA R	10.0	0.0							.5			
96 PYRO SEC U	10.0	0.0					.5					
97 PYRO VIR E	10.0	0.0										
98 SIUM SUA V	10.0	0.0		.5								
99 SOLI DEC U	10.0	0.0	.5									.5
100 SOLI NIS P	10.0	0.0						.5				
101 SOLI SP	10.0	0.0										
S LAYER												
102 SCHI PUR P	60.0	1.0	.5		.5	.5	.5		.5	.5	06	01
103 SRYZ ASP E	30.0	0.5	02			.5			03	.5		.5
104 CALA CAN A	30.0	0.5		.5	04			.5				
105 SRYZ PUR S	20.0	0.1	.5			.5						
106 AGRO TRA C	10.0	0.0		.5								
107 BROM INE R	10.0	0.0	.5								.5	
108 CALA INE X	10.0	0.0										
B LAYER												
109 BRAC SP	80.0	0.7	.5		.5			02	.5	02	.5	
110 PLEU SCH B	20.0	0.0					25			15		
111 CERA PUR P	20.0	0.1	.5								.5	
112 MNIU SP	20.0	0.1						01	.5			
113 POLY PIL I	10.0	0.2	02							.5		
114 HYLO SPL E	10.0	0.0										

LEVEL | ZONE | ASSC | TYPE

ECOSYM UNIT | | | |

PICE GLA-PSPU TRE/CORY COR/ARAL HUD

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0003	000 0005	000 0006	000 0007	000 0008	000 0009	000 0020	000 0032	000 0040	000 0041
NUMBER OF SPECIES PER PLOT	36.8		39	39	38	46	39	44	34	32	38	38
SPECIES	%P	MC	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV	%C SV
L LAYER												
115 CLAD MIT I	10.0	0.1	01									
116 CLAD COC C	10.0	0.0	.5									
117 CLAD GRA C	10.0	0.0	.5									
118 CLAD RAN S	10.0	0.0	.5									
119 CLAD VER T	10.0	0.0	.5									
120 PELT SP	10.0	0.0	.5									

LEVEL | ZONE | ASSC | TYPE
ECOSYM UNIT

THUJ OCC/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0010		000 0011		000 0036	
NUMBER OF SPECIES PER PLOT	38.7		34		33		43	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV
A1 LAYER								
1 PICE GLA U	66.7	6.3	15				10	
2 THUJ OCC I	33.3	20.0			60			
A2 LAYER								
THUJ OCC I	100.0	16.3	20		05		30	
3 POPU TRE M	33.3	6.7	20					
PICE GLA U	33.3	1.7	05					
4 POPU BAL S	33.3	1.7	05					
5 ABIE BAL S	33.3	1.3	04					
B1 LAYER								
THUJ OCC I	66.7	1.6	05				.5	
B2 LAYER								
THUJ OCC I	100.0	3.8	10		01		.5	
6 ROSA ACI C	100.0	0.6	.5		.5		.5	
ABIE BAL S	66.7	2.6	04				.5	
7 CORN STO L	66.7	0.6			01		.5	
8 CORY COR N	66.7	0.6			.5		01	
9 [illegible] VIL L	66.7	0.3			.5		.5	
10 RIBE GRY A	66.7	0.3	.5		.5			
11 VACC VIT I	33.3	0.3					01	
12 LEDU GRO S	33.3	0.3					.5	
13 LONI DIO I	33.3	0.3					.5	
POPU BAL S	33.3	0.3					.5	
POPU TRE M	33.3	0.3	.5					
14 RIBE AME R	33.3	0.3			.5			
15 RIBE TRI S	33.3	0.3			.5			
16 SYMP ALB U	33.3	0.3			.5			
17 VIBU EDU L	33.3	0.3	.5					
18 VIBU TRI L	33.3	0.3					.5	
C LAYER								
19 ASTE CIL I	100.0	1.7	.5		.5		04	
20 CARE SP	100.0	1.6	.5		03		01	
21 CORN CAN A	100.0	1.3	.5		.5		03	
22 RUBU PUB E	100.0	1.3	.5		.5		03	
23 EQUI SCI R	100.0	1.0	.5		03		.5	
24 MITE NUD A	100.0	0.6	.5		.5		.5	
25 LINN BOR E	66.7	1.7	03				03	
26 SMIL TRI P	66.7	0.6			.5		02	
27 SMIL STE L	66.7	0.6	.5		01			
28 ARAL NUD I	66.7	0.3			.5		.5	
29 ORTH VIR O	66.7	0.3			.5		.5	
30 CALT PAL W	66.7	0.3			.5		.5	
31 EQUI ARV E	66.7	0.3			.5		.5	
32 EQUI PRA T	66.7	0.3			.5		.5	
33 FRAG VIR O	66.7	0.3	.5				.5	
34 MAIA CAN A	66.7	0.3	.5				.5	
35 PYRO SEC U	66.7	0.3	.5				.5	
36 TARA OFF I	66.7	0.3	.5		.5			

LEVEL | ZONE | ASSC | TYPE
ECOSYM UNIT

THUJ OCC/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0010		000 0011		000 0036	
NUMBER OF SPECIES PER PLOT	38.7		34		33		43	
SPECIES	%P	MC	%C	SV	%C	SV	%C	SV
37 VIOL ADU I	66.7	0.3	.5				.5	
38 PETA PAL M	33.3	0.7					02	
39 ASTE COR S	33.3	0.2			.5			
40 CARE GYN O	33.3	0.2					.5	
41 CLIN BOR E	33.3	0.2			.5			
42 COPT TRI P	33.3	0.2					.5	
43 EQUI SYL V	33.3	0.2					.5	
44 GALI TRP L	33.3	0.2	.5					
45 GALI TRI P	33.3	0.2			.5			
46 GEUM SP	33.3	0.2					.5	
47 HABE HYP E	33.3	0.2					.5	
48 HELE DEF L	33.3	0.2			.5			
49 IRIS VER S	33.3	0.2					.5	
50 LILI PHI L	33.3	0.2			.5			
51 OSMO SP	33.3	0.2	.5					
52 PETA SAG I	33.3	0.2					.5	
53 PYRO SEC R	33.3	0.2	.5					
54 [illegible] PUB R	33.3	0.2	.5					
55 STEL MED I	33.3	0.2					.5	
56 TRIE BOR E	33.3	0.2					.5	
57 VICI AME R	33.3	0.2	.5					
G LAYER								
58 CALA CAN A	33.3	0.2					.5	
D LAYER								
59 HYLO SPL E	100.0	13.5	.5		12		36	
60 BRAC SP	66.7	0.5	.5		01			
61 CLIN BOR D	33.3	1.7			05			
62 PLAG SP	33.3	0.2	.5					

LEVEL | ZONE | ASSC | TYPE
ECOSYM UNIT

PICE MAR/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0014	000 0024
NUMBER OF SPECIES PER PLOT	34.0		33	35
SPECIES	%P	MC	%C SY	%C SY
A1 LAYER				
1 PICE MAR I	100.0	45.0	59	40
B1 LAYER				
2 THUJ OCC I	100.0	3.5	03	05
B2 LAYER				
THUJ OCC I	100.0	4.0	01	07
3 LEDU GRO E	100.0	1.8	.5	02
4 CORN STO L	100.0	1.0	01	01
5 RIBE SP	100.0	0.5	.5	.5
6 RIBE TRI S	100.0	0.5	.5	.5
7 ALNU RUG S	50.0	0.5		01
8 ROSA ACI C	50.0	0.5	01	
9 RUBU IDA E	50.0	0.5	01	
10 VACC VIT I	50.0	0.5		01
11 AMEL ALN I	50.0	0.3	.5	
12 BETU PAP Y	50.0	0.3	.5	
13 GAUL PRO C	50.0	0.3		.5
14 LONI DIO I	50.0	0.3	.5	
15 LONI VIL L	50.0	0.3		.5
16 SHYC GUA S	50.0	0.3		.5
17 VIBU EDU L	50.0	0.3	.5	
C LAYER				
18 CORN CAN A	100.0	3.5	03	04
19 RUPU PUB E	100.0	3.0	02	03
20 LIGU SOR E	100.0	3.0	02	02
21 MITE GUD A	100.0	0.5	.5	01
22 ASTE CIL I	100.0	0.5	.5	.5
23 CARE GYN G	100.0	0.5	.5	.5
24 EQUI ARV E	100.0	0.5	.5	.5
25 EQUI SCI R	100.0	0.5	.5	.5
26 GALI TRF L	100.0	0.5	.5	.5
27 VIOL REN I	50.0	1.0		02
28 ARAL NUD I	50.0	1.0		02
29 SMIL TRI P	50.0	0.5		01
30 CARE SP	50.0	0.5	01	
31 COPT TRI P	50.0	0.5		01
32 CARE CON M	50.0	0.3	.5	
33 FRAG VIR G	50.0	0.3	.5	
34 HABE OBT H	50.0	0.3		.5
35 MAIA CAN A	50.0	0.3	.5	
36 MONE UNI P	50.0	0.3		.5
37 PETA PAL M	50.0	0.3	.5	
38 PRUN VUL S	50.0	0.3	.5	
39 PYRO ASA R	50.0	0.3		.5
S LAYER				
40 CALA CAN A	50.0	0.3		.5
S LAYER				
41 PLEU SCH R	100.0	37.5	35	40

LEVEL | ZONE | ASSC | TYPE
ECOSYM UNIT

PICE MAR/PLEU SCH

PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0014	000 0024
NUMBER OF SPECIES PER PLOT	34.0		33	35
SPECIES	%P	MC	%C SY	%C SY
42 HYLO SPL S	100.0	20.3	40	.5
43 BICR SP	100.0	2.0	01	03
44 SPHA ESP	50.0	13.5		35
45 AULO PAL U	50.0	0.3		.5
46 BRAC SP	50.0	0.3	.5	
47 TOME HIT S	50.0	0.3		.5

LEVEL	ZONE	ASSC	TYPE
ECOSYM UNIT			

OUTLIER

RESOURCE INVENTORY
EDMONTON, ALBERTA
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PRESENCE (%P), MEAN COVER (MC), PERCENT COVER (%C), SOCIABILITY (S), VIGOR (V)

PLOT NUMBER	AVERAGE VALUE		000 0022	
NUMBER OF SPECIES PER PLOT	23.0		23	
SPECIES	%P	MC	%C	SV
A1 LAYER				
1 PINU BAN K	100.0	20.0	20	
B2 LAYER				
2 ARCT UVA	100.0	7.0	07	
3 VACC ANG U	100.0	4.0	04	
4 GAUL PRO C	100.0	1.0	01	
5 ROSA ACI C	100.0	1.0	01	
6 AMEL ALN I	100.0	0.5	.5	
7 JUNI COM M	100.0	0.5	.5	
8 SPIR ALB A	100.0	0.5	.5	
C LAYER				
9 ANEM QUI R	100.0	1.0	01	
10 APOC AND R	100.0	1.0	01	
11 ASTE LAE V	100.0	0.5	.5	
12 CAMP ROT U	100.0	0.5	.5	
13 SALI BOR E	100.0	0.5	.5	
14 MAIA CAN A	100.0	0.5	.5	
15 POTE TRI D	100.0	0.5	.5	
16 SOLI DEC U	100.0	0.5	.5	
G LAYER				
17 ANDR GER A	100.0	1.0	01	
18 ORYZ PUN G	100.0	0.5	.5	
D LAYER				
19 DICR SP	100.0	18.0	18	
20 PLEU SCH R	100.0	10.0	10	
L LAYER				
21 CLAD RAN G	100.0	30.0	30	
22 CLAD MIT I	100.0	12.0	12	
23 CLAD STE L	100.0	0.5	.5	

SUMMARY VEGETATION TABLE

RESOURCE INVENTORY
EDMONTON, ALBERTA
PAGE 1

ECOSYSTEMATIC UNITS																
SPECIES	PRESENCE CLASS AND MEAN SPECIES SIGNIFICANCE															
ABIE BAL S	II	0.2					I	1.2	IV	3.6						
ACTA RUB R							I	0.1								
AGOS GLA U					I	0.6										
AGRO SCA S	IV	0.2														
AGRO TRA C							I	0.0								
ALNU CRI S							I	0.3								
ALNU RUG S			I	1.0	I	0.6	I	0.7			III	0.5				
AMEL ALN I	II	0.2	V	1.6	V	1.4	III	1.0			III	0.3	V	0.6		
ANDR GER A	IV	0.2	I	0.3	II	0.1							V	1.0		
ANEM MUL T					II	0.1										
ANEM PAT E			I	0.1	I	0.0										
ANEM QUI R	II	0.2	V	0.5	V	0.7	IV	0.4					V	1.0		
ARTE RAC E			II	0.2	II	0.2	I	0.0								
APIR ALB U					I	0.0										
APOC AND R	IV	0.2	V	0.5	III	0.2	I	0.1					V	1.0		
ARAL RUD I	II	0.2	I	0.2	I	0.2	III	1.2	IV	0.2	III	1.0	V	7.0		
ARCT UVA	IV	10.7	V	4.7	V	0.4	I	0.7								
ARTE CAM F	II	0.2														
ARTE LUD S					II	0.1										
ASCL SP					I	0.1										
ASTE CIL I			I	0.1	II	0.2	IV	0.5	V	1.7	V	0.5				
ASTE CON S							I	0.1	II	0.2						
ASTE LAE V	II	0.2	V	0.5	IV	0.4							V	0.5		
ASTE SP							I	0.0								
AULO PAL U											III	0.3				
BETU PAP V			I	0.1	I	0.0	I	0.0			III	0.3				
BETU PUM I							I	1.1								
BOTR VIR G							II	0.1	IV	0.3						
BRAC SP			II	0.3	I	0.1	III	0.7	IV	0.5	III	0.3				
BROM INE R							I	0.0								
CALA CAN A					I	0.0	II	0.5	II	0.2	III	0.3				
CALA INE X							I	0.0								
CALA PAL U					I	0.0										
CALT PAL U									IV	0.3						
CAMP ROT U	II	0.2	V	0.4	III	0.3	I	0.0					V	0.5		
CARE CON N											III	0.3				
CARE GYN O									II	0.2	V	0.5				
CARE RIC N	II	0.2	II	0.2	II	0.1										
CARE SIC C	II	0.2			I	0.0										
CARE SP					I	0.1	I	0.1	V	1.5	III	0.5				
CEAN GVA T			I	0.2												
CERA PUR P	II	0.3					I	0.1								
CHIM UMB E					II	0.2										
CHUM UMB E			I	0.1												
CIRS SP							I	0.1								
CLAD CEC C	II	0.2					I	0.0								
CLAD GRA C	II	0.2	I	0.1			I	0.0								
CLAD MIT I	V	2.6	I	0.1	III	0.4	I	0.1					V	12.0		
CLAD MUL T	II	1.0	I	0.1	I	0.1										

ECOSYSTEMATIC UNITS								
SPECIES	PRESENCE CLASS AND MEAN SPECIES SIGNIFICANCE							
CLAD RAN S	V 3.7	II 0.2	IV 4.6	I 0.0			V 30.0	
CLAD SP		I 0.1						
CLAD STE L			I 0.0				V 0.5	
CLAD VAC I	II 0.2		I 0.1					
CLAD VER T	II 0.2			I 0.0				
CLIN BOR B					II 1.7			
CLIN BOR S				I 0.0	II 0.2			
CLIN PAL L		II 0.2		I 0.0				
CONA PAL L					II 0.2	III 0.5		
COPT TRI P		I 0.2	I 0.3					
CORN ALT S		I 1.2	I 0.3	III 3.5	V 1.2	V 3.5		
CORN CAN A	II 0.2		I 0.1	III 1.2	IV 0.5	V 1.0		
CORN STO L		II 0.2	I 0.1	II 2.0	IV 0.5			
CRAT CRU S			I 0.1					
CYPR ACA S								
DICR SP	V 0.2	IV 1.0	V 2.5			V 2.0	V 10.0	
DIER LON I			I 0.1	I 0.0				
DISP TRA C				II 0.1				
EPIC ASP S			I 0.0					
EPIL ANG N	II 0.2	II 0.2	II 0.2	II 0.2				
EQUI ARV E				II 0.1	IV 0.2	V 0.5		
EQUI LAE V		II 0.2	II 0.2	I 0.0				
EQUI PRA T					IV 0.2			
EQUI SCI R					V 1.0	V 0.5		
EQUI SYL V			I 0.0	I 0.0	II 0.2			
FRAG VIR S		III 0.7	III 0.5	V 1.5	IV 0.3	III 0.3		
FRAX PEN N				I 1.0				
GALI BOR E		III 0.3	IV 0.4	V 0.5			V 0.5	
GALI TRP L		I 0.1	I 0.0	II 0.1	II 0.2	V 0.5		
GALI TRI P				I 0.0	II 0.2			
GAUL PRO C	IV 0.5	III 0.2	III 0.5	I 0.0		III 0.3	V 1.0	
GEUM SP					II 0.2			
GOOD REP S			I 0.0					
HABE HYP E					II 0.2			
HABE OBT U						III 0.2		
HELE SEP L				I 0.0	II 0.2			
HEUC RIC H		I 0.1	I 0.0					
HIER SP			I 0.0					
HIER SP.			I 0.0					
HIER UMB E		I 0.1						
HUDS TOM E	II 0.2							
HUDS TOM E	II 0.2							
HYLO SPL E			I 0.0	I 0.0	V 13.5	V 30.3		
IRIS VER S				I 0.0	II 0.2			
JUNI COM H	II 0.2	I 0.2	II 0.2				V 0.5	

ECOSYSTEMATIC UNITS								
SPECIES	PRESENCE CLASS AND MEAN SPECIES SIGNIFICANCE							
LARI LAR I				I 0.7				
LATH OCH O		V 1.2	III 1.0	IV 0.4				
LEDU GRO E				I 1.1	II 0.2	V 1.5		
LILI PHI L					II 0.2			
LINN BOR E		II 0.2	II 0.5	II 0.4	IV 1.7	V 3.0		
LITH CAR E		IV 0.2	IV 0.2					
LONI DIO I		I 0.1						
LONI DIO I		IV 0.2	II 0.2	III 0.2	II 0.2	III 0.2		
LONI INV O				I 0.0				
LONI VIL L				I 1.5	IV 0.2	III 0.2		
LYCO CON P		I 0.2						
LYSI TER O				I 0.1				
MAIA CAN A	IV 1.0	V 5.5	V 1.7	V 1.4	IV 0.2	III 0.2	V 0.5	
MELA LIN E	II 0.2	I 0.1	I 0.1	I 0.1				
MENT ARV E			I 0.0	I 0.0				
MITE NUD A				I 0.0	V 0.5	V 0.5		
MITE NUD I				I 0.0				
MOLU SP				I 0.1		III 0.2		
MONO UNI P								
ORYZ ASP E	II 0.2	V 4.5	V 1.5	III 0.5			V 0.5	
ORYZ PUN E	V 0.7	V 0.4	V 0.4	I 0.1	II 0.2			
OSMO SP	I					III 0.2		
OXYC QUA O								
PELT MAL A		I 0.1						
PELT SP				I 0.0				
PETA PAL W				III 0.4	II 0.2	III 0.2		
PETA SAG I			I 0.0	I 0.0	II 0.2			
PIBA SAR K			I 1.5					
PICE GLA W				II 0.5	IV 0.2			
PICE MAR I				I 0.5		V 45.0		
PINU BAN K	V 19.0	V 19.7	V 20.0	I 3.5			V 20.0	
PINU RES I				I 2.0				
PLAG SP					II 0.2			
PLEU SCH R		IV 7.5	V 55.3	I 4.0		V 37.5	V 10.0	
POLY JUN I		I 0.2						
POLY PIL I	II 0.7			I 0.2				
POPU BAL S				I 0.0	II 1.7			
POPU TRE M		I 0.1		III 13.0	II 0.7			
POTE PRU T				I 0.0			V 0.5	
POTE TRI S		III 0.3	III 0.3					
PRUN PEN N	II 0.2		I 0.1	I 0.0				
PRUN VIR S	II 0.7	V 0.5	IV 0.4	I 0.3				
PRUN VUL S				I 0.0		III 0.3		
PTER AQU I		I 0.5	I 0.2	I 3.5				
PTIL CRI C			I 0.1					
PYRO ASA S				I 0.0	II 0.2	III 0.3		
PYRO ELL I				I 0.1				
PYRO SEC W	II 0.2	III 0.3		I 0.0	IV 0.3			

ECOSYSTEMATIC UNITS																
SPECIES	PRESENCE CLASS AND MEAN SPECIES SIGNIFICANCE															
PYRO VIR S							I 0.0									
QUER MAC R			I 0.2													
RHUS RAD I					I 0.0		I 0.3									
RIBE AME R									II 0.2							
RIBE GLY A					I 0.0		I 0.0		IV 0.3							
RIBE SP					I 0.0		III 0.3				V 0.5					
RIBE TRI S			I 0.1		I 0.1		I 0.1		II 0.2		V 0.5					
ROSA ACI C	IV 0.3		V 3.5		V 1.6		V 3.2		V 0.5		III 0.5		V 1.0			
RUBU IDA S	II 0.2		III 0.5		II 0.1		I 0.2				III 0.5					
RUBU PUB S					I 0.2		II 0.6		V 1.3							
RUPU PUB S					I 0.0		II 0.3		II 0.2		V 2.5					
SASE SER S					I 0.0											
SALI SER S			II 0.5		I 0.1		I 0.1									
SALI SP							I 0.6									
SALI XSP							I 0.3									
SCMI PUN P	II 0.2		IV 1.0		V 0.5		IV 1.0									
SELA RUP S	II 0.7															
SERE PAU P	II 0.2															
SHEP CAN A			I 0.1		I 0.0		I 0.1									
SIUM SUA V							I 0.0									
SMIL STE L					I 0.0		III 0.3		IV 0.5							
SMIL TRI P									IV 0.5		III 1.0					
SOLI DEC S	II 0.2		I 0.1		II 0.2		I 0.0						V 0.5			
SOLI NIS P	IV 0.3		I 0.1		III 0.3		I 0.0									
SOLI SP			I 0.1		I 0.0		I 0.0									
SPHA SSP											III 13.5					
SPIR ALB A					I 0.1		II 0.3						V 0.5			
SPIR ALB U	II 1.0		I 0.1		II 0.1		I 0.0									
STEL MED I									II 0.2							
SYAM ALB U			I 0.2													
SYMP ALB U	II 0.2		V 1.3		IV 0.5		III 1.1		II 0.2							
TARA OFF I							I 0.1		IV 0.3							
THAL DAS Y							I 0.1									
THAL VER U			II 0.4		I 0.3		I 0.1									
THUJ OCC I							I 0.0		V 16.3		V 4.0					
TOME MIT S											III 0.3					
TRIE BOR S			I 0.1		I 0.1		I 0.1		II 0.2							
TSUG OCC I							I 0.3									
VACC AMO U	IV 4.2		V 3.7		V 3.1		III 1.6						V 4.0			
VACC VIT I									II 0.2		III 0.5					
VIBU EDU L									II 0.2		III 0.3					
VIBU RAF S							I 0.0									
VIBU RAF I			I 0.1				I 0.0									
VIBU TRI L							I 0.5		II 0.2							
VICI AME R			II 0.2		I 0.1		II 0.2		II 0.3							
VIOL ADU M			I 0.1		III 0.3		II 0.1									

ECOSYSTEMATIC UNITS																
SPECIES	PRESENCE CLASS AND MEAN SPECIES SIGNIFICANCE															
VIOL RED I							I 0.1		IV 0.3		V 0.5					

APPENDIX III

SITE DATA SUMMARY

SITE DESCRIPTION SUMMARY

VARIABLE	PLOTS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Elevation (m)	320	320	320	320	327	320	320	312	320	320	320	330	320	327	327	336	336	336	336	320	327
Landform	GF	GF	GF	GF	GF	GF	GF	GL	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF
Subregion	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
Site Position:																					
Macro	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Meso	CREST	MID	MID	UP	LEV	LOW	MID	LOW	MID	LEV	LEV	UP	LEV	LEV	MID	UP	MID	LOW	LOW	MID	MID
Soil Subgroup	EDYB	EDYB	OEB	EDYB	OG	OLGL	OEB	GLEEB	OGL	OG	RG	EDYB	GLEEB	RG	EDYB	EEB	EDYB	OEB	EDYB	OGL	EDYB
Soil Series	SDI	SDI	WOG	SDI	MNT	WQE	PRG	WQE	PRG	SUW	SUW	SDI	WQE	SUW	SDI	PRG	SDI	WOG	SDI	WOG	SDI
Moist Regime (1-8)	2	2	2	3	7	6	4	6	5	7	7	2	6	7	3	5	2	5	2	3	2
Nutrient Regime (1-8)	2	2	2	2	4	3	3	5	4	5	6	2	4	6	2	4	2	3	2	3	2
Soil Drainage (1-6)	1	1	1	1	5	4	3	4	3	5	5	1	4	5	1	1	1	1	1	2	1
Humus:																					
Form	FMOR	FMOR	FMOR	FMOR	FHMOR	FMOR	FMOR	FMOR	FMOR	FHMOR	HMOR	FMOR	FMOR	HMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR
Depth (cm)	3	3	0	3	15	5	5	8	4	10	20	2	3	30	4	2	3	4	2	3	1
Solum Depth (cm)	70	65	-	66	25	30	40	30	35	15	20	70	70	30	70	40	60	30	130	25	60
Texture:																					
A Horizon	LS	LS	-	LS	FSL	LMS	-	L	LFS	-	-	LMS	LMS	-	LFS	LMS,MS	MS	-	MS	MS	FS
B Horizon	MS	MS	GMS	MS	MS	L	LS	SICL	SCL	LCS	-	MS	MS	LMS	MS	MS	MS	MS	CS	SL	MS
C Horizon	GS	MS	MS	MS	MS	MS	SL	SCL	LCS	CS	SCL	GCS	GMS	GMS	LFS	GCS	MS	MS	MS	GCS	FS
Coarse Fragments:																					
A Horizon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
B Horizon	0	2	0	2	0	5	20	5	5	5	0	0	10	0	17	10	0	0	10	50	5
C Horizon	20	5	20	2	0	0	20	0	5	0	0	30	30	20	0	30	10	30	30	30	0
Family Particle Size	S	S	S	S	S	CL	FL	S	S	FL	FL	S	S	S	S	S	S	S	S	S	S
Soil pH:																					
LFH or Organic	5.7	5.5	-	-	6.3	5.7	-	6.6	6.5	7.1	7.9	6.5	-	-	4.8	-	6.1	-	-	-	6.2
A or Organic	5.4	5.9	-	6.4	6.6	6.2	-	7.5	6.2	7.2	-	5.9	-	-	6.5	-	6.1	-	-	-	6.5
B or Organic	5.7	5.9	-	6.4	7.0	6.7	7.7	7.7	6.5	7.9	-	6.4	-	-	5.7	-	5.6	-	-	-	6.3
C or Organic	6.4	6.2	-	7.6	6.6	6.5	-	6.4	-	6.4	6.4	7.9	-	-	5.0	-	-	-	-	-	-
Tree Species:	JP	JP	RP	JP	L	TA	BS	WS	TA	WS	EC	JP	JP	BS	JP	JP	JP	JP	JP	WS	JP
DBH (cm)	31.8	23.7	14.6	26.6	17.9	29.9	13.4	30.1	26.5	36.8	32.4	34.1	16.6	22.4	16.7	19.4	21.2	23.6	23.7	44.2	16.5
Height (m)	17.5	13.5	-	16.5	16.5	18.5	10.0	33.0	24.0	27.0	19.5	16.5	15.0	18.5	17.5	14.5	16.5	16.5	67.5	24.0	16.0
Vol (cu.m/ha)	101.8	79.4	-	108.5	16.7	98.9	150.9	624.9	430.6	412.5	225.1	183.5	70.1	188.1	156.1	77.4	141.9	39.6	120.8	157.0	68.7
Age (yr)	74	65	17	76	73	UND	42	86	UND	82	196	76	43	82	46	72	57	56	57	99	47
S.I.	13.7	11.9	11.9	-	13.7	-	11.3	21.3	-	20.4	15.2	13.1	16.8	13.7	11.9	15.2	15.2	15.2	15.2	17.1	16.2
M.A.I. (cu.m/ha)	1.19	1.03	-	-	.19	-	2.67	5.36	-	3.94	-	2.09	1.30	1.93	2.72	.93	2.07	.99	1.77	1.36	1.30

SITE DESCRIPTION SUMMARY

VARIABLE	PLOTS 22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Elevation (m)	327	335	327	335	358	358	335	350	360	366	320	320	320	366	366	360	335	320	315	360
Landform	GF	GF	BAGF	BV	GF	GF	GF	E	GF	GF	GF	GF	GF	GF	GF	GF	GF	E	GF	GF
Subregion	21.02	21.02	21.02	21.02	21.01	21.01	21.02	21.01	21.01	21.01	21.02	21.02	21.02	21.01	21.01	21.01	21.02	21.02	21.02	21.01
Site Position: Macro	P	P	P	P	UP	UP	P	P	UP	UP	P	P	P	UP	UP	UP	P	P	P	UP
Meso	UP	MID	LEV	MID	LEV	LEV	MID	CR	MID	MID	LOW	LOW	LOW	LEV	CR	LEV	LOW	CR	MID	MID
Soil Subgroup	EDYB	OGL	TM	EEB	EDYB	EDYB	EEB	EDYB	EDYB	EDYB	GLEDYB	GLEDYB	EEB	EDYB	EDYB	EDYB	OG	EDYB	GLEDYB	GLGL
Soil Series	SDI	PRG	RTV	PRG	SDI	SDI	PRG	KTS	SDI	SDI	LSD	LSD	PRG	SDI	KTS	SDI	SUW	KTS	LSD	PRG
Moist Regime (1-9)	2	3	6	2	3	3	3	2	2	2	6	6	3	3	2	2	6	2	6	6
Nutrient Regime (1-6)	2	3	5	2	2	2	3	1	1	1	3	4	3	2	1	1	5	1	3	4
Soil Drainage (1-6)	1	2	6	1	2	1	1	1	1	1	4	4	1	1	1	1	5	1	4	4
Humus: Form	FMOR	FMOR	FHMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	FMOR	HPMOR	FMOR	FMOR	FMOR
Depth (cm)	1	2	60	2	2	1	2	1	1	4	4	2	2	2	0.5	3	35	1	2	2
Solum Depth (cm)	80	37	60	45	50	55	28	35	55	60	35	45	42	65	25	60	40	45	40	30
Texture: A Horizon	MS	MS	0	MS	LFS	LFS	MS	MS	LFS	LFS	MS	MS	LMS	LFS	LFS	MS	0	MS	MS	LMS
B Horizon	MS	LS	0	MS	FS	LFS	SL	MS	FS	LFS,MS	MS	MS	GS	MS	FS	MS	MS	MS	MS,VFS	CL
C Horizon	GS	CS	C	GCS	SL	LFS	CS	MS	MS	S	MS	L	MS	MS	S	S	MS	MS	CS	FS
Coarse Fragments: A Horizon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B Horizon	0	0	0	7	0	0	2	0	0	0	5	2	20	0	0	2	0	0	0	0
C Horizon	2	2	0	20	10	0	0	0	0	0	5	0	10	0	0	0	0	0	0	0
Family Particle Size	S	S	FC	S	CL	S	S	S	S	S	S	FL	S	S	S	S	S	S	S	S
Soil pH: LFH or Organic	-	-	6.9	-	-	5.8	-	5.7	-	-	5.5	5.3	6.3	5.5	-	5.9	7.0	-	-	5.6
A or Organic	-	-	7.0	-	-	5.7	-	5.9	5.7	-	5.6	5.0	6.3	5.6	5.8	5.9	-	-	-	6.1
B or Organic	-	-	-	-	-	5.4	-	6.1	6.2	-	6.1	5.9	7.1	6.1	5.9	6.0	7.7	-	-	7.5
C or Organic	-	-	6.6	-	-	-	-	-	-	-	6.1	6.4	7.9	-	-	-	6.1	-	-	6.2
Tree Species:	JP	JP	BS	JP	JP	JP	JP	JP	JP	JP	JP	JP	JP	JP	JP	JP	WS	JP	TA	JP
DBH (cm)	23.8	17.8	18.3	8.2	27.4	18.0	24.7	15.2	21.9	17.0	13.9	21.8	18.4	17.9	10.6	20.3	43.9	18.8	18.4	26.9
Height (m)	21.5	16.5	14.0	5.8	17.6	14.0	16.5	11.0	17.5	16.5	12.5	18.0	15	15.0	6.0	14.5	22.5	16.5	18.0	18.5
Vol (cu.m/ha)	252.9	162.6	136.2	0.0	163.0	84.1	116.6	25.9	105.1	108.1	5.8	160.8	144.0	94.2	2.6	91.9	145.2	170.8	115.4	64.8
Age (yr)	80	58	109	15	67	55	74	29	49	50	28	46	52	53	15	54	73	52	36	UND
S.I.	19.2	11.9	9.8	11.9	16.2	13.1	13.4	16.5	14.2	16.6	16.6	19.2	14.6	14.6	16.8	13.7	18.0	16.2	21.6	-
M.A.I. (cu.m/ha)	3.57	2.36	1.10	0.0	2.39	1.26	1.36	.64	1.73	1.74	.15	2.83	2.27	1.46	.10	1.40	1.66	2.70	3.21	-

Tree Data

PLOT	SPP	DBH	HT	BHAGE	SI	TOTVOL	MAI
1	JP	31.8	17.5	74	13.7	101.63	1.19
2	JP	23.7	13.5	65	11.9	79.37	1.03
3	RP	14.6	-	17	11.9	-	-
4	JP	25.6	15.5	76	-	106.54	-
5	TL	17.9	16.5	73	13.7	16.74	.19
6	TA	29.9	18.5	-	-	98.85	-
7	BS	13.4	10.0	42	11.3	150.89	2.67
8	WS	39.1	33.0	85	21.3	524.94	5.39
9	TA	26.5	24.0	-	-	420.57	-
10	WS	35.8	27.0	92	20.4	412.45	3.94
11	EC	32.4	19.5	195	15.2	225.07	-
12	JP	34.1	16.5	76	13.1	183.53	2.09
13	JP	16.8	15.0	43	16.8	70.13	1.30
14	WS	22.4	18.5	82	13.7	188.07	1.93
15	JP	16.7	17.5	46	11.9	158.14	2.72
16	JP	19.4	14.5	72	15.2	77.35	.93
17	JP	21.2	16.5	57	15.2	141.87	2.07
18	JP	23.6	16.5	56	15.2	39.61	.59
19	JP	23.7	16.5	57	15.2	120.83	1.77
20	WS	44.2	24.0	99	17.1	156.98	1.39
21	JP	16.5	16.0	47	16.2	69.70	1.20
22	JP	23.8	21.5	60	19.2	252.90	3.57
23	JP	17.8	16.5	58	19.9	162.55	2.36
24	BS	16.3	14.0	109	9.8	136.16	1.10
25	JP	8.2	5.8	15	11.9	.00	.00
26	JP	27.4	17.5	57	16.2	162.96	2.39
27	JP	18.0	14.0	55	13.1	84.10	1.26
28	JP	24.7	16.5	74	13.4	116.56	1.36
29	JP	15.2	11.0	29	16.5	25.86	.64
30	JP	21.9	17.5	49	14.2	105.14	1.73
31	JP	17.0	18.5	50	18.6	106.07	1.74
32	JP	13.9	12.5	28	18.6	5.83	.15
33	JP	21.8	18.0	46	19.2	160.76	2.83
34	JP	18.4	15.0	52	14.6	143.99	2.27
35	JP	17.9	15.0	53	14.6	94.24	1.46
36	JP	10.6	6.0	15	16.8	2.55	.10
37	JP	20.3	14.5	54	13.7	91.90	1.40
38	WS	43.9	22.5	73	18.0	145.16	1.68
39	JP	18.8	16.5	52	16.2	170.77	2.70
40	TA	18.4	18.0	36	21.6	115.39	3.21
41	JP	26.9	18.5	-	-	64.77	-

Missing Values of MAI are due to 1 or more of the following:

- TOTVOL not calculated because 1+ trees had missing hts, etc.
- Total Age could not be determined (TOTAGE is a function of BHAGE and SI so if either of these variables are missing we can't determine MAI).

APPENDIX IV

SOIL SERIES DESCRIPTIONS

SOIL LAB DATA

SOIL SERIES DESCRIPTIONS

These are brief soil series descriptions taken from the Canada - Manitoba Soil Survey catalogue of soil series.

Kettlehills Series

The Kettlehills series consists of rapidly drained Orthic Regosols and Dystric Brunisols developed on stone-free eolian or glaciofluvial sands. Topography is irregular varying from gently to moderately sloping sand dunes. Internal drainage is very rapid and runoff is negligible. The native vegetation consists of widely spaced jack pine forest with a very sparse understory dominated by bearberry and Cladonia.

Kettlehills soils are characterized by a relatively thin, undecomposed lichen layer overlying a thin, light brownish gray Ae horizon (often absent), a yellowish brown Bm horizon (may be absent) and a light yellowish BC horizon. Sand textures occur throughout the profile and the solum is very strongly acid. These soils are relatively infertile with low organic matter contents and very low cation exchange capacities. They are highly susceptible to wind erosion if surface cover is removed.

Pine Ridge Series (PRG)

The Pine Ridge series consists of well drained Eluviated Eutric Brunisol soils developed on moderately calcareous, sandy, deltaic and lacustrine deposits. Surface textures are loamy fine sand to sand. The topography is very gently sloping to irregular gently sloping. Permeability is rapid. Native vegetation consists dominantly of jack pine.

The Pine Ridge soils are developed on sandy deposits with a very low clay content and consequently, the accumulation in the B horizon is usually very low. Frequently the B horizon is developed in a thin gravel lense comprised of decomposing dolostones coated with silt and clay. Very often, the B horizon is not continuous, and the horizon appears as an Aeg and Btj or Bm horizon. If a Bt of Btj is present as a minor inclusion in the map area, the Aej is thick often extending 50 cm or more below the surface.

Rat River Series (RTV)

The Rat River Series consists of poorly drained Terric Mesisol soils developed on shallow (40 to 160 cm) deposits of mesic forest peat underlain by coarse to moderately coarse textured lacustrine sediments. The organic portion has a very thin (<15 cm) fibric moss peat layer, and underlain by dominantly mesic grading into humic forest peat. The mesic forest peat is very dark brown, slightly acid to neutral, fine fibered, sticky material layered with variable amounts of woody debris. This layer grades into black, highly decomposed peat which may be of fen or forest origin. The native vegetation consists of productive stands of black spruce with some tamarack and understory of Labrador Tea, and feathermoss. Sphagnum moss is of limited occurrence being found as small raised hummocks.

Sandilands Series (SDI)

The Sandiland series consists of moderately well to well drained Eluviated Dystric Brunisols developed on siliceous sandy outwash deposits. These deposits are usually quite thick and appear to have been reworked by water and wind. The topography is irregular, gently sloping. Internal drainage is very rapid and runoff is negligible. The native vegetation consists dominantly of Jack pine forest with an understory of low ericaceous shrubs, lichens, herbs and grass species.

Sandilands soils have weakly developed horizons distinguished by faint changes in color and reaction. They have a thin discontinuous organic layer, a thin, light brownish gray A horizon, and an indefinite Bm (BFJ) that grades gradually into very pale brown fine sand which may contain slight amounts of lime carbonate below a metre of the surface.

Sundown Series (SUW)

The Sundown series consists of poorly drained Rego Humic Gleysol, carbonated phase soils developed on thick, stratified, strongly calcareous sand and gravel deposits which are greater than a metre thick and usually underlain by loamy glacial till. Usually a thin (<15 cm) strata of moderately coarse to fine textured sediments occurs at the surface. They occur in level to depressional areas bordering gravelly beach ridges or in narrow swales. Runoff is very slow, but lateral movement of water through the gravelly layers is common. The

vegetation is mainly sedges, meadow grasses and reeds, with scattered clumps of willow, tamarack and black spruce.

The soil is characterized by a moderately decomposed black fen peat layer of 6 to 15 cm thick, and thin (10 to 15 cm) granular, black A horizon and abruptly into the light gray sand and gravel C horizon. The sand and gravel deposits may extend for a considerable depth below the surface.

Sundown peaty phase have been mapped in the area. A 15 to 40 cm layer of mesic fen peat covers the mineral soil surface.

Wintergreen Series (WGE)

The Wintergreen series consists of imperfectly drained, Gleyed Gray Luvisol soils developed on strongly calcareous, sandy lacustrine and outwash deposits. Surface textures are fine sand to fine sandy loam. The topography is level to irregular, very gently sloping. Soil permeability is rapid, but internal drainage is impeded by a high ground water table. Native vegetation is comprised of pure stands of jack pine; mixed jack pine, aspen, balsam poplar, birch; a dense understory of tall and short shrubs like dogwood, rose, alder, raspberry, currant, saskatoon; a profusion of herbs; and some grasses. The soils are stone-free.

The soil is characterized by a thin 2 to 5 cm leaf litter, and a 8-12 cm dark yellowish brown Btg with clay coating on the peds and grades through a thin transition area to the C horizon and then to the IIC.

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SDI - Sandilands

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8802 - SW36-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	3-0	5.5	-	-	-	-	-	20	0.47
Ahe	0-3	5.9	-	91	4	5	S	1.8	0.03
Bm_1	3-25	5.9	-	96	4	0	S	0.5	0.30
Bm_2	25-55	6.1	4.8	95	0	5	S	-	
BC	55-110	6.6	5.0	95	0	5	S	-	
Ck	110-130	8.2	-	96	3	1	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	3-0	-	-	-	-
Ahe	0-3	5.2	2.84	0.39	0.0
Bm_1	3-25	2.4	1.40	0.24	0.0
Bm_2	25-55	0.6	0.97	0.20	0.0
BC	55-110	-	-	-	-
Ck	110-130	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: WGE - Wintergreen

SOIL CLASSIFICATION: Eluviated Eutric Brunisol

SITE NUMBER AND LOCATION: 8808 - SW31-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	8-0	6.6	-	-	-	-	-	77	0.32
Ahe	0-5	7.5	-	55	20	25	SCL	14	0.61
Btj	5-30	7.7	7.1	66	16	18	SCL	-	.12
Ckg	30-80	8.4	-	37	22	41	CL	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	8-0	-	-	-	-
Ahe	0-5	-	35.60	10.46	-
Btj	5-30	15.6	14.71	5.17	15.6
Ckg	30-80	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SUW - Sundown

SOIL CLASSIFICATION: Orthic Gleysol

SITE NUMBER AND LOCATION: 8810 - SW33-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	10-4	7.1		-	-	-	-	81	1.55
H	4-0	7.2		-	-	-	-	30.2	0.91
Bm	0-16	7.9		83	10	7	LS	0.7	0.03
Ckg	16-50	8.4		87	4	9	LS		

Horizon	(cm)	CEC	Exchangeable (me/100 g) Ca	Mg	Na
LF	10-4	-	-	-	-
H	4-0	-	34.07	5.60	0.0
Bm	0-16	8.6	9.53	1.70	0.0
Ckg	16-50	-	-	-	-

Note: This is not a typical Sundown soil, but there is no better series concept to fit.

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SDI - Sandilands

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8815 - NE10-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	4-0	4.9	-	-	-	-	-	51	0.83
Ae	0-20	8.5	-	79	6	15	SL	0.3	0.01
Bm_1	20-45	5.9	5.0	91	3	6	S	1.1	0.51
Bm_2	45-70	5.6	4.6	93	4	3	S	-	
Ck	70-100	5.0		89	5	6	S	-	

Horizon	(cm)	CEC	Exchangeable (me/100 g) Ca	Mg	Na
LF	4-0	-	-	-	-
Ae	0-20	2.6	22.27	0.91	0.0
Bm_1	20-45	3.6	0.59	0.27	0.0
Bm_2	45-70	-	-	-	-
Ck	70-100	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: RTV - Rat River

SOIL CLASSIFICATION: Terric Fibric Humisol

SITE NUMBER AND LOCATION: 8824 - SE3-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
OF	0-30	6.9	-	-	-	-	-	72	1.12
OH	30-60	7.0	-	-	-	-	-	65	0.08
Ckg	60-85	7.9	-	91	0	9	S	-	
2Ckg	85-120	8.6	-	53	3	44	SC	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
OF	0-30	-	-	-	-
OH	30-60	148.8	-	-	-
Ckg	60-85	-	-	-	-
2Ckg	85-120	-	-	-	-

Note: This profile does not fit well into the established soils concepts. The sand layer underlying the peat is usually of greater thickness than at this site.

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: KTS - Kettlehills

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8829 - NE25-5-9E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	1-0	5.7	-	-	-	-	-	2.6	0.55
Ae	0-3	5.9	-	95	4	1	S	1.1	0.06
Bm	3-35	6.1	4.9	95	5	0	S	0.5	0.08
BC	35-100	6.2	-	95	0	5	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	1-0	-	-	-	-
Ae	0-3	3.0	0.95	0.25	0.20
Bm	3-35	1.2	0.26	0.08	0.0
BC	35-100	-	-	-	-

Note: This soil could also be called a Sandilands, but it is developed on a sand dune, and is therefore called a Kettlehills.

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: LSD - Lonesand

SOIL CLASSIFICATION: Gleyed Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8832 - NW11-7-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	4-0	5.5	-	-	-	-	-	61	0.02
Ae	0-15	5.6	-	91	4	5	S	0.6	0.02
Bm	15-35	6.1	5.0	94	5	1	S	-	
Ckg	75-120	8.1	-	93	5	2	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	4-0	-	-	-	-
Ae	0-15	1.6	1.77	0.35	0.0
Bm	15-35	-	-	-	-
Ckg	75-120	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SDI - Sandilands

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8835 - SE6-6-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N
LF	2-0	5.5	-	-	-	-	-	50	1.21
Ae	0-14	5.6	-	88	4	8	LS	1.2	0.08
Bm_1	14-30	5.9	5.0	94	3	3	S	0.8	0.06
Bm_2	30-65	6.4	5.6	93	5	2	S	-	
BC	65-120	6.4	-	89	3	8	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	2-0	-	-	-	-
Ae	0-14	3.2	3.47	0.47	0.0
Bm_1	14-30	2.6	3.99	0.27	0.0
Bm_2	30-65	-	-	-	-
BC	65-120	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: KTS - Kettlehills

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8836 - NW28-5-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
Ahe	0-8	5.8	-	93	4	3	S	2.7	0.06
Bm	8-25	5.9	4.8	94	0	6	S	1.6	0.05
BC_1	25-75	6.1	-	94	5	1	S	-	
BC_2	75-120	6.4	-	98	0	2	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
Ahe	0-8	4.0	2.48	0.43	0.0
Bm	8-25	2.8	0.99	0.31	0.0
BC_1	25-75	-	-	-	-
BC_2	75-120	-	-	-	-

Note: This profile could also be called a Sandilands,but it is developed on a sand dune and is therefore called a Kettlehills.

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SDI - Sandilands

SOIL CLASSIFICATION: Eluviated Dystric Brunisol

SITE NUMBER AND LOCATION: 8837 - NW19-5-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
LF	3-0	5.9	-	-	-	-	-	40	1.12
Ahe	0-3	5.9	-	93	6	1	S	1.9	0.10
Bm_1	3-15	5.9	4.8	93	5	2	S	0.5	0.11
Bm_2	15-60	6.1	5.3	03	5	2	S	-	
BC_1	60-90	6.4	-	97	0	3	S	-	
BC_2	90-120	6.7	-	96	0	4	S	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
LF	3-0	-	-	-	-
Ahe	0-3	5.2	3.14	0.60	0.0
Bm_1	3-15	2.8	3.02	0.09	0.0
Bm_2	15-60	-	-	-	-
BC_1	60-90	-	-	-	-
BC_2	90-120	-	-	-	-

SOIL CHARACTERIZATION ANALYSES

SOIL NAME: SUW - Sundown

SOIL CLASSIFICATION: Peaty Orthic Gleysol

SITE NUMBER AND LOCATION: 8838 - SE18-6-10E

Horizon	Depth (cm)	H_2O pH	CaCl pH	% of <2 mm Sand	Silt	Clay	Texture	OM%	N%
OH	25-0	7.0	-	-	-	-	-	65	1.81
Bg	0-15	7.7	6.7	92	6	2	S	1.7	0.01
BCg	15-40	7.7	-	92	5	3	S	-	
Ckg	40-75	8.1	-	86	5	9	LS	-	

Horizon	(cm)	Exchangeable (me/100 g) CEC	Ca	Mg	Na
OH	25-0	158.0	-	-	-
Bg	0-15	13.2	8.73	1.33	0.0
BCg	15-40	-	-	-	-
Ckg	40-75	-	-	-	-

APPENDIX V

LIST OF PLANT SPECIES

LIST OF PLANT SPECIES

TREES

Abies balsamea (L.) Mill.
Betula papyrifera Marsh.
Fraxinus pennsylvanica Marsh. var. austini Fern.
Larix laricina (du Roi) K. Koch
Picea glauca (Moench) Voss
Picea mariana (Mill.) BSP
Pinus banksiana Lamb.
Pinus resinosa Ait.
Populus balsamifera L.
Populus tremuloides Michx.
Quercus macrocarpa Michx.
Thuja occidentalis L.

SHRUBS

Alnus crispa (Ait.) Pursh
Alnus rugosa (Du Roi) Spreng. var. americana (Regel) Fern.
Amelanchier alnifolia Nutt.
Betula glandulosa Michx.
Ceanothus ovatus Desf.
Cornus alternifolia L.f.
Cornus stolonifera Michx.
Corylus cornuta Marsh.
Diervilla lonicera Mill.
Juniperus communis L.
Ledum groenlandicum Oeder
Lonicera dioica L. var. glaucescens (Rydb.) Butters
Lonicera villosa (Michx.) R. & S. var. solonis (Eat) Fern.
Potentilla fruticosa L.
Prunus pensylvanica L.f.
Prunus virginiana L.
Rhus radicans L. var. rydbergii (Small) Rehd.
Ribes americanum Mill.
Ribes oxyacanthoides L.
Ribes triste Pall.
Rosa woodsii Lindl. / R. acicularis Lindl.
Rubus idaeus L.
Salix bebbiana Sarg.
Shepherdia canadensis (L.) Nutt.
Spiraea alba Du Roi
Symphoricarpos albus (L.) Blake
Symphoricarpos occidentalis Hook.
Vaccinium angustifolium Ait.
Viburnum edule (Michx.) Raf.
Viburnum rafinesquianum Schultes
Viburnum trilobum Marsh.

HERBS AND DWARF SHRUBS

Actaea rubra (Ait.) Willd.
Agoseris glauca var. dasycephala Jepson
Agropyron trachycaulum (Link) Malte
Agrostis scabra Willd.
Andropogon gerardi Vitman
Anemone multifida Poir.
Anemone patens L. var. wolfgangiana (Bess.) Koch
Anemone quinquefolia L. var. interior Fern.
Apocynum androsaemifolium L.
Aralia nudicaulis L.
Arctostaphylos uva-ursi (L.) Spreng.
Artemisia caudata Michx.
Artemesia ludoviciana var. pabularis (Nels.) Fern.
Aster ciliolatus Lindl.
Aster laevis L.
Aster lateriflorus (L.) Britt.
Aster puniceus L.
Botrychium virginianum (L.) Sw.
Bromus pumpellianus Scribn.
Calamagrostis canadensis (Michx.) Nutt.
Calamagrostis inexpansa Gray
Caltha palustris L.
Campanula rotundifolia L.
Carex castanea Wahl.
Carex concinna R.Br.
Carex gynocrates Wormskj.
Carex richardsonii R. Br.
Carex siccata Dew.
Chimaphila umbellata (L.) Bart. var. occidentalis (Rydb.) Blake
Clintonia borealis (Ait.) Raf.
Comandra pallida (Richards.) Fern.
Coptis trifolia (L.) Salisb. var. groenlandica (Oeder) Fassett
Cornus canadensis L.
Cypripedium acaule Ait.
Disporum trachycarpum (Wats.) B. & H.
Epigaea repens L. var. glabrifolia Fern.
Epilobium angustifolium L.
Equisetum arvense L.
Equisetum laevigatum A.Br.
Equisetum pratense Ehrh.
Equisetum scirpoides Michx.
Equisetum sylvaticum L.
Fragaria virginiana Duchesne
Galium boreale An.
Galium trifidum L.
Galium triflorum Michx.
Gaultheria procumbens L.
Goodyera repens (L.) R.Br. var. ophioides Fern.
Habenaria hyperborea (L.) R.Br.
Halenia deflexa (Sm.) Griseb.
Heuchera richardsonii R.Br.

HERBS AND DWARF SHRUBS (Cont'd)

Hieracium umbellatum L.
Hudsonia tomentosa Nutt.
Iris versicolor L. Lathyrus ochroleucus Hook.
Lilium philadelphicum L.
Linnaea borealis L. var. americana (Forbes) Rehd.
Lithospermum canescens (Michx.) Lehm.
Lycopodium complanatum L.
Lysimachia terrestris (L.) BSP.
Maianthemum canadense Desf.
Melampyrum lineare Desr.
Mentha arvensis L. var. villosa (Benth.) Stewart
Mitella nuda L.
Monotropa uniflora L.
Oryzopsis asperifolia Michx.
Oryzopsis pungens (Torr.) Hitchc.
Oxycoccus quadripetalus Gilib.
Petasites palmatus (Ait.) Gray
Petasites sagittatus (Pursh) Gray
Potentilla tridentata Ait.
Pteridium aquilinum (L.) Kuhn var. latiusculum (Desv.) Underw.
Prunella vulgaris L. var. lanceolata (Barton) Fern.
Pyrola asarifolia Michx.
Pyrola elliptica Nutt.
Pyrola secunda L.
Rubus pubescens Raf.
Schizachne purpurascens (Torr.) Swallen
Selaginella rupestris (L.) Spring
Senecio pauperculus Michx.
Sium suave Walt.
Smilacina stellata (L.) Desf.
Smilacina trifolia (L.) Desf.
Solidago decumbens Greene var. oreophila (Rydb.) Fern.
Solidago hispida Muhl.
Stellaria media (L.) Cyrillo
Taraxicum officinale Weber var. americanus Schultes
Thalictrum dasycarpum Fisch. & Lall.
Thalictrum venulosum Trel.
Trientalis borealis Raf.
Vaccinium vitis-idaea L. var. minus Lodd.
Vicia americana Muhl.
Viola adunca Sm.
Viola renifolia Gray

MOSSES

Aulacomnium palustre (W.&M.) Schw.
Ceratodon purpureus (Hedw.) Brid.
Climacium dendroides Web. & Mohr
Hylocomium splendens (Hedw.) B.S.G.
Pleurizium schreberi (Brid.) Mitt.

MOSSES (Cont'd)

Polytrichum juniperinum Hedw.
Polytrichum piliferum Hedw.
Ptilium crista-castrensis (Hedw.) De Not.
Sphagnum fuscum (Schimp.) Klinggr.
Tomenthypnum nitens (Hedw.) Loeske

LICHENS

Cladonia coccifera (L.) Willd.
Cladonia gracilis (L.) Willd.
Cladonia mitis Sandst.
Cladonia multiformis Merr.
Cladonia rangiferina (L.) Wigg.
Cladonia stellaris Opiz
Cladonia uncialis (L.) Wigg.
Cladonia verticellata (Hoffm.) Schaer.
Peltigera malacea (Ach.) Funck

APPENDIX VI

REVIEW OF RELEVANT FOREST ECOLOGY LITERATURE (partly annotated)

Alan, David H., Donald A. Perala & Bryce E. Schlaegel. 1978. Biomass and nutrient distribution in aspen, pine, and spruce stands on the same soil type in Minnesota. Can. J. For. Res. 8(3): 290-299.

Past agricultural use of sandy soils in eastern North America resulted in poor growth of subsequently planted red pine, which could be corrected by K fertilization.

...incidence of serious nutrient depletion can be expected to increase as more intensive forest management removes more nutrients through thinnings, shorter rotation and more complete tree utilization. Nutrients in total above ground tree as a percent of nutrients in the 36 cm soil layer:

Element	Red Pine	Jack Pine
N	13	10
P	54	35
K	58	35
Ca	7	5
Mg	18	12

soil >36 cm was excluded because of the small number of roots below this depth

Jack pine removes a smaller percent of soil nutrients than red pine. There are potential deficiencies of P & K, for red pine.

Knowledge of nutrient solubilization rates in forest soils is limited, which makes it difficult to interpret the significance of nutrient removal from a site.

Our knowledge of fixation rates, weathering and mineralization of organic matter in forest ecosystems as well as species nutritional needs is fragmentary, so definite conclusions about the effect of nutrient removal by timber harvesting cannot be made at this time.

...above ground tree removal puts a 2- to 11-times greater drain on the site (depending on tree species and nutrient) than only if bole wood is removed. Since the amount of foliage, branches and bark associated with a given amount of bole wood can be reduced by controlled spacing (Singer & Hutnik 1966; Stiell 1966) it may be possible to reduce nutrient drains without sacrificing yields by the proper adjustment of spacing.

Andersen, Chris P., Edward I Sucoff and Robert K. Dixon. 1986. Effects of root zone temperature on root initiation and elongation in red pine (Pinus resirosa) seedlings. Can. J. For. Res. 16(4): 696-700.

Bergeron, Yves & Daniel Gagnon. 1987. Age structure of red pine (Pinus resinosa Ait) at its northern limit in Quebec. Can. J. For. Res. 17(2): 129-137.

Mechanisms involved in red pine maintenance can be discussed at 2 levels: 1) within individual populations of red pine maintenance is controlled by localized fires and windthrow, which create permanent openings in the canopy, allowing the establishment of self-regenerating uneven age populations. 2) at the landscape level the maintenance of red pine could be achieved through a mosaic of several populations shifting in time to different parts of the landscape as new openings created by fire become available.

Bottenfield, T.R. 1986. Soil-site relationships in red pine plantations in upper Michigan. M.S. thesis, School of Forestry and Wood Products, Michigan Technological University, Houghton, MI.

Fowells, H.A. 1965. Red pine (Pinus resinosa Ait.) Silvics of Forest Trees of the United States. U.S. Dept. of Agriculture, Agriculture Handbook No. 271: 432-446.

Red pine grows in areas characterized by cool-to-warm summers, cold winters, rather low to moderate rainfall, sandy soils, and level to rolling topography. Chiefly on acid soils with good drainage and aeration.

Fowler, D.P. and D.T. Lester. 1970. Genetics of red pine. USDA For. Serv., Res. Pap. W0-8.

Fowler, D.P. and R.W. Morris. 1977. Genetic diversity in red pine: evidence for low genic heterozygosity. Can. J. For. Res. 7(2): 343-347.

Red pine has a low degree of genetic variation for higher levels of genetic organization i.e. within & between plant populations. It is concluded that red pine is genetically depauperate. The most plausible explanation suggests that red pine was at sometime, possibly during the Pleistocene, reduced to a small refugial population and has yet to reestablish equilibrium heterozygosity.

Davis (1976) suggests that red pine was restricted to the southeastern U.S. at the culmination of the last major glacial period (20,000 yrs ago) and completed its northern migration into its present range only 8-11,000 yrs. ago. The possibility that contemporary red pine is derived from a single refugial population established sometime during the Pleistocene is not remote.

Gevorkiantz, S.R. 1957. Site index curves for red pine in the Lake States. USDA Forest Serv., Lake States Forest Exp. Stn, Tech. Note 484, 2 p.

Haig, R.A. and J.H. Cayford. 1960. Factors affecting survival and growth of red pine plantations in southeastern Manitoba. Can. Dep. North. Aff. Natl. Resour., For. Br., For. Res. Div., Ottawa, Ont., Tech. Note 93, 17 p.

Horton, K.W. and W.G.E. Brown. 1960. Ecology of white and red pines in the Great Lakes - St. Lawrence Forest Region. Can. Dep. North. Aff. Natl. Res. For. Branch Tech. Note No. 88.

Horton, L.W. and G.H.D. Bedell. 1960. White and red pine ecology, silviculture and management. Can. Dep. North. Aff. Natl. Res., For. Branch Bull. No. 124.

Logan, K.T. 1966. Growth of tree seedlings as affected by light intensity. II. Red pine, white pine, jack pine and eastern larch. Can. Dep. Fish. For., For. Res. Branch, Publ. No. 1160.

Lundgren, A.L. and W.A. Dolid. 1970. Biological growth functions describe published site index curves for Lake States timber species. U.S. For. Serv. Res. Pap. NC-36.

Martin, G.L. 1978. A dynamic network analysis of silvicultural alternatives for red pine. Ph.D thesis, Univ. Wis-Madison (Univ. Microfilms 7902416). 189 p.

Perala, Donald A. 1985. Predicting red pine shoot growth using growing degree days. For. Sci. 31: 913-925.

A modified Weibull function accurately described the seasonal shoot growth of red pine as a function of growing degree day (GDD) sums for five seasons at one station in Minnesota.

...the GDD model seems capable of providing sufficiently reliable estimates to identify relatively warm, moderate, and cool growing regions to improve the timing of silvicultural applications related to plant maturity. With calibration of reference stations, the model may be sufficiently sensitive to aid analysis of thermal variability of forested microclimates, to estimate the effects of water stress, or other activities requiring more precise estimates.

Pereira, J.S. and T.T. Kozlowski. 1977. Water relations and drought resistance of young Pinus banksiana and P. resinosa plantation trees. Can. J. For. Res. 7(1): 132-137.

Jack pine appeared to avoid drought better than red pine because the former maintained a higher needle water potential throughout most of the season. This reflected lower transpiration and slower soil water depletion associated with lower leaf area and stomatal closure at higher needle water potential in jack pine.

Jack pine has a thinner crown than red pine and thus a much lower stomata-bearing surface than red pine.

Jack pine appears to close stomata earlier in the day than red pine.

Jack pine maintain higher water potential values than red pine in the early season when soil water was readily available, evaporative demand low and the young needles not fully expanded.

Under these conditions jack pine had a better water balance between its transpiring and water-absorbing surfaces (whether this was related to larger root systems and lower surface area or to lower root resistance to water flow in the system, assuming that stem and leaf resistances to liquid water flow can be neglected in comparative terms, is not shown).

Rudolf, Paul O. 1957. Silvical Characteristics of Red Pine. USDA For. Serv., Lake States Forest Experiment Station. Station Paper No. 44. 32 pp.

Singer, F.P. and R.J. Hutnik. 1966. Accumulation of organic matter in red pine and Norway spruce plantations at various spacings. Penn. State Univ. Res. Briefs, 1:22-28.

Schlaegel, Bryce E. 1975. Yields of four 40-year-old conifers and aspen in adjacent stands. Can. J. For. Res. 5(2): 278-280.

Volume and dry-weight yield comparisons of 40-yr-old planted red pine, jack pine, white spruce, black spruce and a naturally regenerated aspen sucker stand show that red pine has the highest yields and black spruce the lowest. Volume yields: aspen = jack pine = white spruce.

Wt. yields: white spruce << jack pine or aspen.
Yield comparisons within and between species should be done on a weight as well as a volume basis because large differences in density can occur.

Study area: gentle undulating till plain with a deep ground water table.

Simon, Jean-Pierre, Yves Bergeron and Daniel Gagnon. 1986. Isozyme uniformity in populations of red pine (Pinus resinosa) in the Abitibi Region, Quebec. Can. J. For. Res. 16(5): 1133-1135.

Stiell, W.M. 1978. Characteristics of eastern white pine and red pine In: White and Red Pine Symposium: 7 51. Great Lakes Forest Res. Centre, Sault Ste. Marie, Ontario, 0-P-6.

Stiell, W.M. 1970. Some competitive relations in a red pine plantation. Dept. of Fisheries and Forestry, Canadian For. Service, Ottawa Publ. (Canadian Forest Service) no. 1275.

Stiell, W.M. 1966. Red pine crown development in relation to spacing. Can. Dep. For. Publ. No. 1145.

Stone, Earl L. and Richard Ksyzystyniak. 1977. Conservation of potassium in the Pinus resinosa ecosystem. Science 197 (4313): 192-194.

Rubidium-potassium ratios were determined on foliage, litter, and surface soils of plots in 2 plantations of Pinus resinosa 41-46 yrs old previously fertilized once with potassium. Calculations based on indigenous soil subsidium as the "tagging" ion demonstrate that after 9 years 60% of the foliage potassium is still derived from the fertilizer and after 23 years about 40% of the foliage potassium is derived from the fertilizer. Additional fertilizer potassium is present in soil & litter, indicating the high retention of this mobile element in the pine ecosystem.

Such prolonged response (to added potassium) can plausibly be attributed to: 1) efficient recycling of the added potassium. 2) pump priming by the initial fertilization; that is recovery from acute deficiency might result in intensive exploration of subsoil layers which often contain reserve potassium (80-300 mg/kg soil).

Sucoff, E. and S.G. Hong. 1974. Effects of thinning on needle water potential in red pine. For. Sci. 20: 25-31.

Sucoff, E. 1972. Water potential in red pine: soil moisture, evapotranspiration, crown position. Ecology. 53: 681-686.

Despite complexity of the red pine crown little variation in leaf water potential was observed among its parts.

Thomas, P.A. and R.W. Wein. 1985. The influence of shelter and the hypothetical effect of fire severity on the postfire establishment of conifers from seed. Can. J. For. Res. 15(1): 148-155.

Surface charred organic matter is a common but unfavourable postfire seedbed in eastern Canada. Slatted screens providing 0, 25, 50, and 75% cover were used to shelter 1-m^2 plots from direct sunlight.

Results: the size and composition of the seedling community depended on the amount of shelter given. Removal of vegetation decreased establishment of Abies balsamea and Picca mariana but not Pinus resinosa. Removal of fire severity (organic matter consumption) may reduce the postfire vegetation cover.

With abundant shelter, the establishment of red pine may be as high as that of Pinus banksiana, but as shelter is reduced survival declines. Eventually, the reduction in organic matter depth is sufficient to compensate for the lack of shelter and the survival of red pine increases. By the time mineral soil is exposed by high fire severity, establishment is again almost as high as that of jack pine.

van Wagner, C.E. 1971. Fire and red pine. Proc. 10th Annu. Tall Timbers Fire Ecology Conf. 10:221-224.

van Wagner, C.E. 1968. Fire behaviour mechanism in a red pine plantation field and laboratory evidence. Can. Dep. North. Aff. Natl. Res. For. Branch Tech. Note No. 88.

Vogl, R.J. 1970. Fire and the northern Wisconsin pine barrens. Proc. Ann. Tall Timbers Fire Ecology Conf. 10: 175-209.

Jack pine is rapid growing, short-lived, serotinous-coned and prolific seeding compared to the long-lived, infrequent-seeding and heavily logged red pine. The composition of pine barrens was apparently determined more by the frequency of fires than by their intensities.

Fire, then, is considered a critical and controlling factor in determining the conifer composition of these barrens. Frequent fires apparently favored jack pine and less frequent fires, or perhaps fire free periods alternating with periods of repeated fires, favored red pine.

The relatively high yields of timber on the original barrens may be related to the role fire played in recycling energy from the ground layer vegetation and litter to the overstory trees, conteracting the infertile sands, arrested decay and low organic matter content.

MAPS
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